POWER PLANT ENGINEERING

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Baltimore's Improved Central Plant

DUE TO GREATLY INCREASED DEMAND, NEW EQUIPMENT HAS BEEN INSTALLED, ADDING 77,500 KW. CAPACITY TO THE PLANT

MANY FACTORS have contributed toward an increased load on the power plant of the Consolidated Gas, Electric Light and Power Co., of Baltimore, Md. Industrial developments in the vicinity, even before the war, were demanding more power than the old plant could handle comfortably, and plans were then being made to enlarge the Westport plant, increasing its capacity greatly. These plans were halted temporarily, however, and it was not until the need of power, during the war, for munitions making was imperative that work on the new part of the plant at Westport was continued.

The original plant was designed before the days of the steam turbine, so when additional power was required, some changes in the plans for extension had to be made. The arrangement adopted is shown in Fig. 4, where it will be noted that the steam feeds from both ends of the plant to the electric generating units at the center. While this arrangement has its disadvantages, in that it separates the boiler rooms, making separate coal and ash handling equipment necessary, it has the

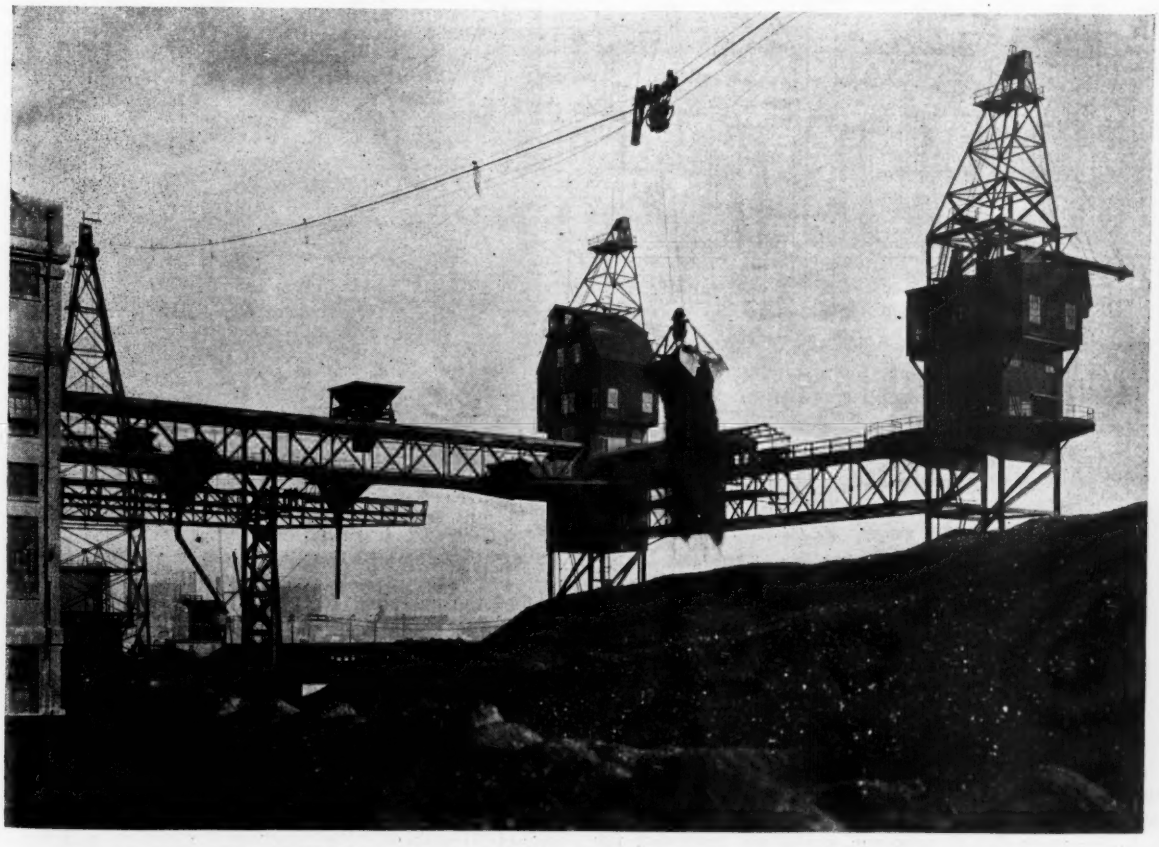


FIG. 1. COAL STORAGE, SHOWING CABLE AND TRAMWAY SYSTEMS FOR COAL HANDLING

distinct advantage of bringing the old boilers, which now serve the turbines, the engines being used only as standby units, close to the point where the steam is used. Any other arrangement would necessitate the transmission of steam a considerable distance.

In boiler room No. 1, space is provided for 10 boilers. Two of these have been removed and the space thus made available has been occupied by the machine shop, which is fully equipped for making all repairs to power plant machinery, except that of planing the heaviest pieces. The eight boilers installed here are of the horizontal water-tube type, each having a rating of 640 hp. Six of these are equipped with eight retort underfeed stokers, while the remaining two are hand fired. Boiler room No. 2 contains four 640-hp. and four 736-hp. boilers, all of the horizontal water-tube type and underfeed stoker fired. Feed-water for all of these boilers is heated in three 5000-hp. open type feed-water heaters by steam from the auxiliaries.

In boiler room No. 1 the coal is fed to the stokers from overhead bunkers, an estimate of the amount used being made from the number of strokes of the stoker. In boiler room No. 2, however, scales are provided for each boiler. Coal is delivered from the water front to one of two skip hoists, which elevate it above the bunkers and these discharge to a belt conveying system for distribution to the various boilers in rooms Nos. 1 and 2. These boilers are served by three stacks located as shown in the general plan, Fig. 4.

The equipment in the old engine room is now held for use in case of emergency. It consists of five direct connected generating units, one of which has a capacity of 5000 kw., with the driving element a cross-compound horizontal type reciprocating engine. The other four units are of the vertical cross-compound type, driving 2000-kw. generators. Three-phase alternating current is delivered to the busses at 13,000 v. and 25 cycles. Barometric condensers maintain the vacuum with harbor water used for condensing purposes.

Naturally it is in the new part of this plant that we find the principal features of interest and, although not complete, the general plans will be followed out in the remainder of the plant that have already been put into operation. This new section, when completed, will have 36 boilers, conveniently arranged in groups of 12. These will supply steam for driving seven turbo generators.

All of the new boilers are of the horizontal water-tube type, each rated at 1047 hp., and equipped with 11-retort underfeed stokers. For driving the stokers and forced draft fans on 12 of the boilers, individual electric motors are employed. The fans are driven through variable speed drives. Each fan is capable of furnishing 40,000 cu. ft. of air per minute, at a pressure of 6 in. of water,

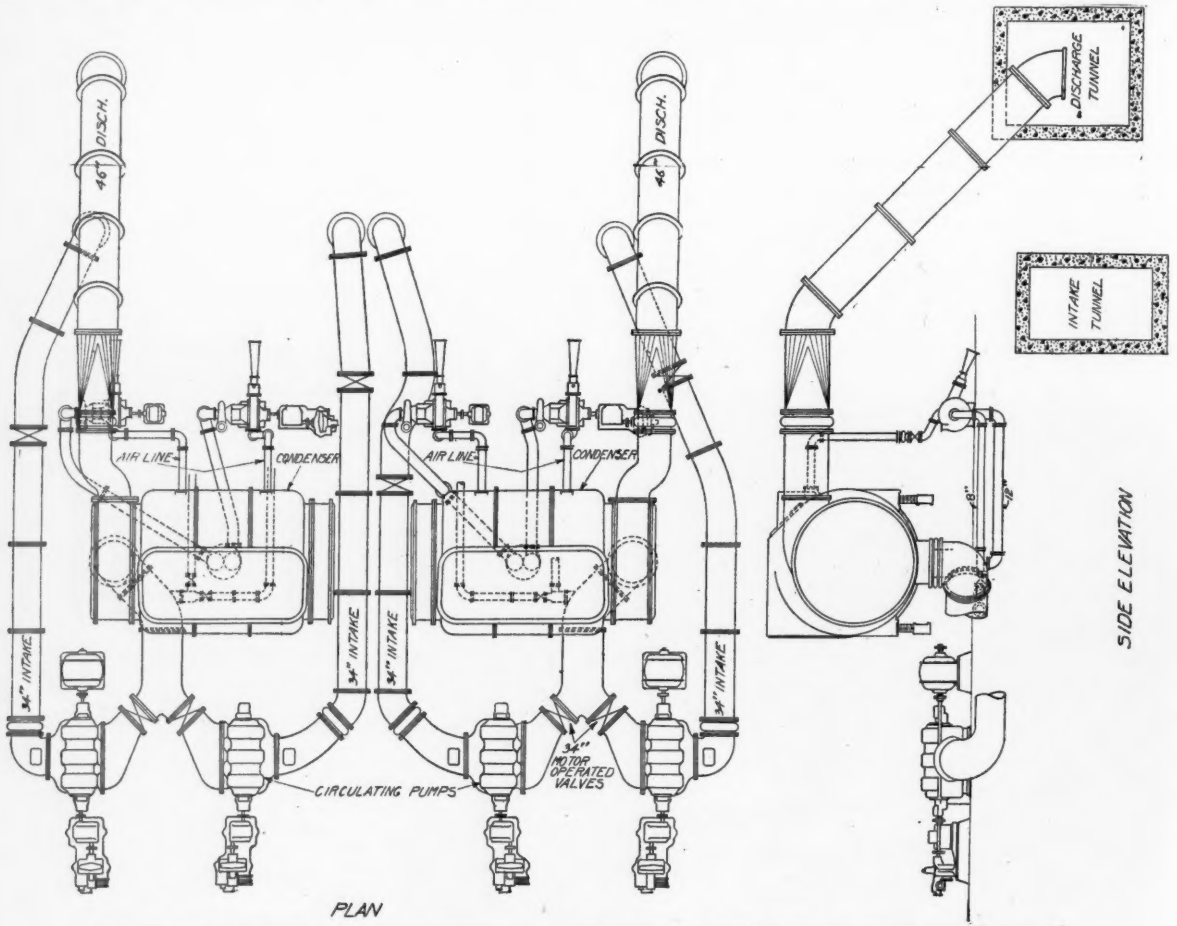


FIG. 2. ARRANGEMENT OF CONDENSERS AND CONDENSER AUXILIARIES FOR UNITS NOS. 9 AND 10

and is driven by a 75-hp. motor. These furnaces are all hand regulated, as are also six of the other units now installed, but operated by group drive. The remaining six, however, have automatic regulation of the fan and stoker speeds. The drive in this case is from a line shaft belted to a steam engine, the speed of which is under the control of a regulator and varies with changes in steam pressure. In operation, the six boilers that are under automatic control take the swing of the load, while the others carry steady loads regulated by hand to give most economical distribution. It is planned to run the boilers at about 200 per cent of their rating. Steam pressure is carried at 200 lb. and superheat at 150 deg.

Each boiler is provided with a submerged type feed-water regulator, two automatic coal scales, a steam flow meter of the indicating and recording type, a three-in-one indicating draft gage, a non-return and a gate valve in each lead, and four safety valves, one set at 203, the others at 205 lb.

Each set of 12 boilers is served by a radial brick stack 30 ft. in diameter at the base and 250 ft. in height above the steel structure supporting it. A recording CO_2 machine is provided for analyzing the gases from each battery of six boilers.

Boilers are set in individual settings and each is provided with a control panel in the firing aisle. Above this aisle are placed reinforced concrete coal bunkers, the

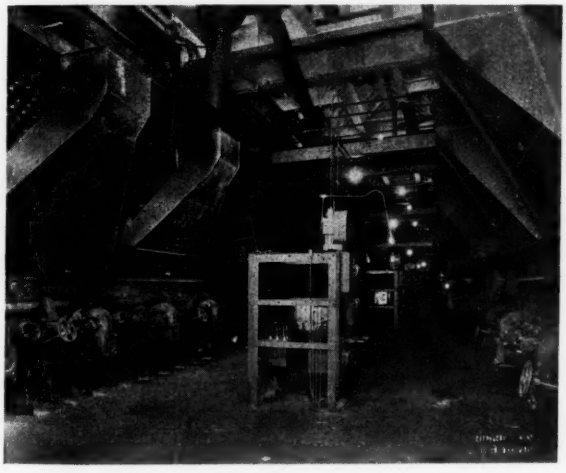


FIG. 3. FIRING AISLE OF ONE OF THE BOILER HOUSES

capacities ranging from 180 to 245 tons per boiler. A view of one of the firing aisles is given in Fig. 3.

Coal comes to the plant in barges and is unloaded to the storage yard by coal handling towers. The yard has capacity for storing thousands of tons of run of mine coal, but it is not expected that the full capacity will be needed. Two towers, one 240 ft. high, the other 90 ft., with a cable between them, are used for storing. The low tower travels, thus giving a sweep of considerable area. This arrangement is shown in Fig. 1.

A tramway system distributes the coal, after it has been crushed, to the boiler bunkers.

Ashes and soot are dumped from hoppers beneath the boilers to side dump cars run on 24-in. gage tracks and wheeled outside the boiler house, where an elevator conveyor delivers them to railway cars for disposal.

Boiler feed water comes from the Patapsco River and is delivered to a primary settling basin. From this basin the water is delivered to a treating house, where it is treated with alum and caustic soda and filtered before delivery to the clear water reservoir.

This filtered water as makeup, together with condensate from the condensers, is delivered to open heaters, which take exhaust steam from the auxiliaries. As the water passes from the heaters, it is metered by recording and integrating meters, which give an accurate idea of the boiler operation. For each set of 12 boilers, three 10,000-hp. heaters are installed, except for boilers Nos. 19 to 30, which are served by only two heaters. Besides the regular metering equipment, one set of water scales is provided for use when testing a boiler.

Among the interesting features of the plant is the feed-water piping system, the plan of which is shown

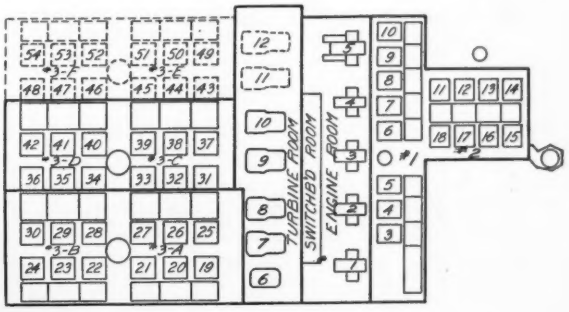


FIG. 4. GENERAL LAYOUT OF WHOLE PLANT

in Fig. 7. A complete double ring of piping is installed in the basement under each set of six boilers. These are designated as main and auxiliary feed lines and have cross connections at each boiler. Water may be fed from two sources and the system of valving permits feeding any boiler from a separate source from the others, thus enabling tests to be made without interfering with the regular operation of the other boilers.

For each set of 12 boilers, four boiler feed pumps are provided and installed in the basement beneath. One of these pumps has a capacity of 1000 g.p.m., two 500 g.p.m., these three being three-stage centrifugal pumps driven by direct connected steam turbines. The fourth has a capacity of 300 g.p.m. and is a five-stage centrifugal pump driven by motor.

With each unit of 12 boilers are provided two centrifugal service pumps, one being steam driven, the other electric, each having a capacity of 500 g.p.m. These supply water for cooling bearings, washing boilers, cooling transformers, etc. There are also a 150-g.p.m. motor driven make-up water pump and two 1000 g.p.m. motor driven raw water pumps that deliver to the heater.

Compressed air at 80 to 100 lb. pressure is furnished by two single stage, double-acting 12 by 14-in. motor driven air compressors. The air is used for driving tools and cleaning purposes.

Salt water from the bay is used for quenching fires in the ashes, and this is pumped by two 300-g.p.m. centrifugal motor driven pumps provided with each unit of 12 boilers. A view of one of the pump rooms is given in Fig. 6.

In the turbine room, only five units have been in

stalled, although, as previously stated, the complete plans call for seven. Unit No. 6 is a 7500-kw. turbine generator of standard design served by two jet condensers. The condenser pumps are driven by a single reciprocating steam engine.

Units Nos. 7 and 8 each have a capacity of 15,000 kw. and are served by low level jet condensers, the circulating water pumps being turbine driven, while the air pumps are driven by motors.

bine with an auxiliary used for the same purposes driven by a motor; a circulating pump driven by steam turbine, and another as an auxiliary, driven by either a turbine or motor, according to the needs of the plant for exhaust steam. Figure 2 shows the condenser and cooling water equipment for units 9 and 10.

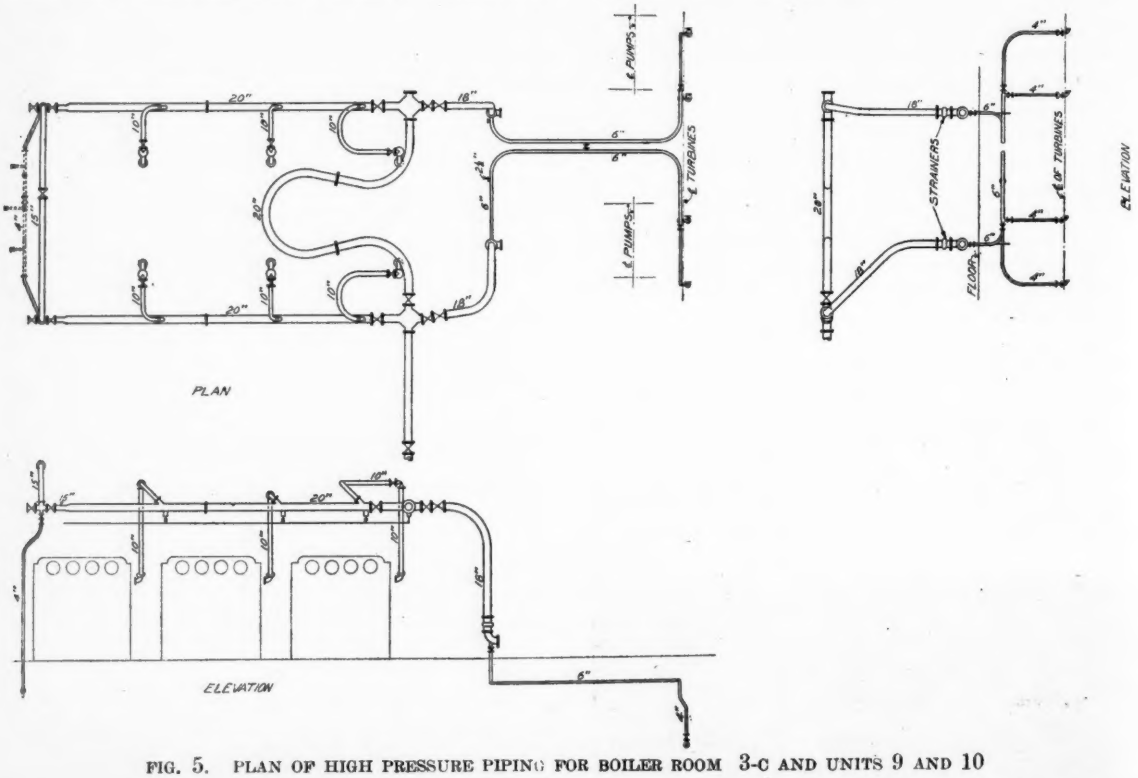


FIG. 5. PLAN OF HIGH PRESSURE PIPING FOR BOILER ROOM 3-C AND UNITS 9 AND 10

FIG. 6. TYPICAL PUMP ROOM IN BOILER HOUSE BASEMENT

The two most recently installed units, Nos. 9 and 10, are each rated at 20,000 kw. at a power factor of 90 per cent. These are served by surface condensers of the radial flow type, each having a condensing surface of 32,000 sq. ft. For each of these units there is a combined air and condensate pump driven by a steam turbine with an auxiliary used for the same purposes driven by a motor; a circulating pump driven by steam turbine, and another as an auxiliary, driven by either a turbine or motor, according to the needs of the plant for exhaust steam. Figure 2 shows the condenser and cooling water equipment for units 9 and 10.

All of the generators deliver three-phase, 25-cycle alternating current at 13,000 v. and, as a protection against overheating, temperature coils are laid in the armatures with indicators on the switchboard. Ventilating air for the generators is conditioned by air washers located on the roof of the turbine room.

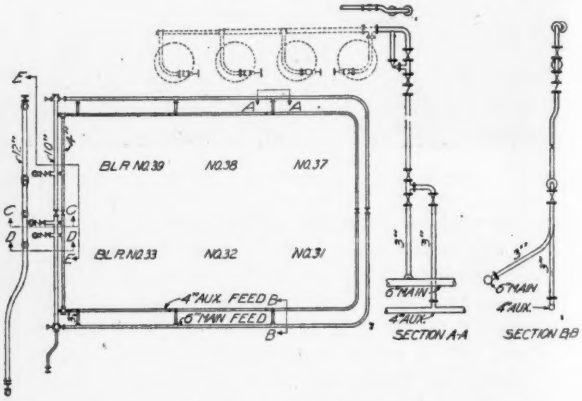


FIG. 7. PLAN OF FEED WATER PIPING

Further protection for these generators is provided

by balanced relays that trip when current reaches two and one-half times the normal rating; also by field destroying device. Automatic reclosing circuit breakers are installed to restore service after momentary short circuits or overloads. Steam piping to these units is unusually direct, as will be noted in Fig. 5, which also shows the location of strainers which protect the turbines from scale or other solid matter which may be driven along with the steam.

Condensing water for all of the units comes from the bay in three 9-ft. tunnels, which are built of concrete lock joint pipe, and returns through tunnels of the same dimensions. Outside the power plant in the intake tunnels are installed vertical traveling screens which clear the condensing water of fish and debris before it enters the condensers.

As will be noted in Fig. 4, the switchboard room is located in the center of the plant. Here there is an instrument post and pedestal control board for each generator with the 13,000-v. remote controlled switches in concrete compartments in a gallery above.

In the second or top gallery are located the transformers and station storage battery; with general distribution from the station is at a voltage of 13,000, some of the lines leading to distant points are carried to 26,000 v. and tie in with the Pennsylvania Water & Power Co. and the United Electric Railway Co., of Baltimore.

By the improvements described above, the plant is not only greatly increased in size, but the equipment, being of the latest designs, higher efficiency will, undoubtedly, be maintained than was possible with the old plant.

Savings Due to Economizer

METHODS OF CALCULATING HEAT TRANSFER, FINAL TEMPERATURES AND NET SAVINGS. BY R. G. BOHN

MANY TIMES an operating engineer is called upon by the owner or superintendent of his plant to make reports or estimates of the probable savings that can be made by making changes or additions to the plant equipment, but more often the engineer must take the initiative when he wants additional equipment of any kind and show how money can be saved in operating expenses by judicious investments. The engineer must realize that the majority of owners and superintendents are not engineers, and, like himself, familiar with engineering terms, but they are business men and understand no terms better than dollars and cents. It is imperative, then, that recommendations be brought to the basis of understanding of a business man, and the engineer's status becomes at once more important in the mind of his employers if he can and does present his arguments in this way. It also may happen that the owners of a plant wish to install some equipment that the engineer believes thoroughly is not adaptable, or that will not make savings that are expected; if he can show reliable figures in support of his opinion and thus prevent the installation, he is saving money just as surely as if proper apparatus were installed, and his value is on the increase. It is generally true that the highest paid men in any organization are the men whose value is apparent every time the owner or superintendent examines his books. A salesman's services are measured in the profits on orders sent in; engineers must in some way obtain a place on the credit side of the ledger and it can be done by applying their engineering knowledge to the business departments.

Economizer installations are a good example of what can be done in the business of engineering, for it is certainly true that a good many plants have economizers that are, instead of saving money, actually causing a loss for every day they operate, and many plants are sending good money up the stack when an economizer would pay a good return on the money invested in it. In order to analyze any plant conditions as to the adaptability for economizer operation, the engineer should have properly kept and reliable records of his operating conditions, and this is true in any other case. In order to bring weight to an argument, its basis must be sound; and no matter how large or small a plant is, there should be available at all times good, honest records of what the plant is doing. Generally quite reliable results can be obtained by intelligent estimates, but every time an estimated figure has to be used in representing an operating condition, it should be sufficient indication that there should have been a record, and now is the time to begin that record.

The most common form of economizer is built of cast-iron tubes, generally 4 in. in diameter and 10 ft. long, set vertically, and attached in rows of 12 tubes, to cast-iron headers or boxes, top and bottom; the headers are interconnected to make up as much surface as required and the whole apparatus enclosed in a sheet steel or brick casing in which the hot flue gases from the boiler uptakes circulate around the outside of the tubes, before being discharged to the stack. The feed-water generally enters the economizer tubes at the end farthest from the boiler and flows in an opposite direction to the flue gases. The water is under the full feed-water pressure, as difficulty in pumping the hot water after leaving the economizer would be certain. Each economizer tube is fitted with an extended soot scraper, which travels slowly up and down the tube and is operated from above the economizer by a motor or engine. Often steam soot blowers are also provided, as it is imperative to maintain clean tubes. A bypass usually is provided around the economizer in order that it may be cut out of service without interfering with the normal boiler operation, and generally an induced draft fan to maintain sufficient draft is necessary.

An understanding of the factors that most influence successful economizer installations is necessary before any conclusions as to what exact results may obtain, can be made. The principal things to remember are as follows:

(1) That under varying conditions an actual saving of coal as high as 15 to 20 per cent may be attained. This does not mean that an economizer will always be a wise investment, however, because the installation

may cost more in operating expenses and interest on the investment, than the coal it saves.

(2) Generally a substantial saving will be made when the boilers are forced well above their rating a large proportion of the time.

(3) The greatest savings will be shown in plants operating condensing with motor driven auxiliaries and with little or no exhaust steam for feed-water heating, which means that the colder the feed-water the greater the possible savings with an economizer.

(4) If open feed-water heaters are installed with an ample supply of exhaust steam that would otherwise be wasted, an economizer quite often will not show a saving.

(5) The higher the temperature of the flue gases discharged from the boiler, the greater the possible saving.

TABLE 1. ECONOMIZER SURFACE AND RESULTING TEMPERATURE

Economizer Surface, Sq. Ft.	n	$10^n - 1$	Temp. Rise Water, deg. F.	Final Water Temp., deg. F.	Final Gas Temp., deg. F.
0			0	100	650
1000	0.0188	0.044	16	116	612
2000	0.0376	0.091	31	131	575
3000	0.0564	0.139	44	144	545
4000	0.0752	0.189	56	156	515
5000	0.0940	0.242	67	167	489
6000	0.1128	0.297	77	177	465
7000	0.1316	0.354	86	186	443
8000	0.1504	0.414	95	195	421
9000	0.1692	0.477	103	203	403
10000	0.1880	0.542	110	210	385
11000	0.2068	0.610	116	216	370
12000	0.2256	0.680	122	222	354
13000	0.2444	0.756	129	229	338
14000	0.2632	0.833	134	234	327
15000	0.2820	0.915	139	239	315
16000	0.3008	0.999	144	244	303
17000	0.3200	1.090	148	248	293

(6) The higher the price of coal per ton, the greater economic saving possible, if the cost of the economizer and its operation does not increase in proportion.

(7) Pure feed-water is quite essential to good economizer operation.

(8) The flue gases should not be cooled below 250 deg. F., because vapor in the gases will be condensed on the cool tubes at the exit of the economizer, and cause soot to adhere; also, if the coal burned contains a high per cent of sulphur, the condensed moisture combines with the sulphur dioxide gas and forms dilute sulphuric acid, and corrosion will result.

A set of plant conditions quite favorable to economizer operation will be assumed and an analysis worked out, and by following the method outlined, but substituting actual plant conditions, it is possible to predict closely what an economizer will do under any set of conditions.

It is assumed that the plant has four water-tube boilers installed with a total heating surface of 20,000 sq. ft., the coal burned has an average heating value of 11,200 B.t.u. per lb., the feed-water temperature is 100 deg. F., and the uptake temperature 650 deg. F. The boilers are normally forced to 200 per cent of their rating of 500 hp., and the efficiency over all is 70 per cent.

The theoretical weight of air required to burn a pound of any coal may be assumed as 7.5 lb. per 10,000 B.t.u., therefore, for the 11,200 B.t.u. coal there will be required

$$1.12 \times 7.5 = 8.4 \text{ lb. of air per lb. of coal}$$

Assuming an excess air of 50 per cent and that the coal contains 18 per cent ash, the actual weight of flue gases per pound of coal burned will be

$$1.5 \times 8.4 + \frac{100 - 18}{100} = 13.42, \text{ or, in round numbers, } 13.50 \text{ lb. of flue gas per lb. of coal.}$$

The boilers will evaporate 3.45 lb. of water per sq. ft. of heating surface per hour, at their rated capacity, and have 20,000 sq. ft. of surface operating at 200 per cent of rating, therefore, the total water evaporated will be

$$2 \times 20{,}000 \times 3.45 = 138{,}000 \text{ lb. of water per hr.}$$

Since an over-all efficiency of 70 per cent was assumed, the weight of coal required per hour under the conditions assumed will be

$$\frac{970.4 \times 138{,}000}{11{,}200 \times 0.70} = 17{,}081 \text{ lb. of coal per hr.}$$

(970.4 = latent heat of vaporization and is constant). The total weight of flue gas per hour is then

$17{,}081 \times 13.42 \div 229{,}227$; say 229,230 lb. flue gas.

It is reasonable to assume the mean specific heat of water as 1 and of the flue gas as 0.25. The coefficient of heat transmission varies from about 5.5 for a gas flow of about 5000 lb. per hr. per sq. ft. of area in the gas passages to about 4 for a flow of 3000 lb. per hr. per sq. ft. of area. We will assume a value of 4.25, which means that the rate of heat transfer from the gases to the water will be 4.25 B.t.u. per sq. ft. of

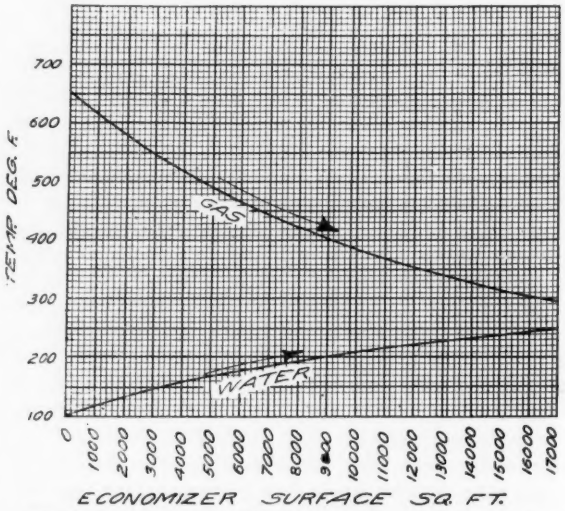


FIG. 1. RELATION BETWEEN ECONOMIZER SURFACE AND WATER AND GAS TEMPERATURES

economizer surface, per hour, per degree of mean temperature difference between the gas and the water.

Now, the heat given up by the flue gas must be equal to the heat absorbed by the water in the economizer, if radiation losses are neglected, and if the economizer is properly covered, this loss will be negligible. Or, in other words, the product of the total weight of water passing through the economizer, its specific heat and its temperature rise must equal the product of the total weight of gas, its specific heat and its temperature drop. Let T_1 equal the temperature rise of the water and T_2 the temperature drop of the gas, then

$$0.25 \times 229{,}230 \times T_2 = 1 \times 138{,}000 \times T_1$$

$$\text{and } \frac{T_2}{T_1} = 2.41$$

Prof. G. F. Gebhardt, in his Steam Power Plant Engineering, gives an expression for the rise in temperature of the feed-water in an economizer as follows:

$$X = \frac{t_2 - t_0}{\frac{N-1}{10^n - 1} + N}$$

In which t_2 = initial temperature of the flue gas

t_0 = initial temperature of the feed-water

$N = \frac{T_2}{T_1}$ or 2.41, as above

$n = \frac{SU(N-1)}{2.3w}$

S = economizer surface in sq. ft.

U = coefficient of heat transmission, we assumed = 4.25

w = total lb. of water going through the economizer per hr.

It is evident that by assuming a value for S we may readily determine n, and then solving for X, the temperature rise of the feed-water, we may determine the final gas temperature from the relation of

TABLE II. ECONOMIZER SURFACE AND YEARLY SAVINGS

Economizer Surface, Sq. Ft.	Per Cent Saving	18% of Economizer Cost, Dollars	Gross Saving, Per Year, Dollars	Net Saving, Per Year, Dollars
1000	1.15	720	1380	660
2000	2.24	1440	2688	1248
3000	3.18	2160	3810	1650
4000	4.04	2880	4850	1970
5000	4.83	3600	5800	2200
6000	5.55	4320	6650	2330
7000	6.20	5040	7450	2410
8000	6.85	5760	8225	2465
9000	7.43	6480	8900	2420
10000	7.93	7200	9516	2316
11000	8.36	7920	10030	2110
12000	8.80	8640	10550	1910
13000	9.30	9360	11240	1880
14000	9.65	10080	11580	1500
15000	10.00	10800	12000	1200
16000	10.40	11520	12500	980
17000	10.70	12240	12820	680

$$\frac{T_2}{T_1} = N = 2.41, \text{ or}$$

$$\frac{t_2 - t_1}{t - t_0} = \frac{T_2}{T_1} = 2.41$$

In which t_2 and t_0 are as denoted before

and t_1 = final gas temperature

t = final water temperature.

If we assume at once an economizer surface of 10,000 sq. ft. and solve for the temperatures and surface requirements, the work is as follows:

$$n = \frac{10{,}000 \times 4.25(2.41 - 1)}{2.3 \times 138{,}000} = 0.188$$

$$X = \frac{650 - 100}{\frac{2.41 - 1}{10^{.188} - 1} + 254} = 110 \text{ deg. F.}$$

The final feed-water temperature is then 100 + 106 = 206 deg. F., and the final gas temperature, since

$$\frac{t_2 - t_1}{t - t_0} = 2.41$$

is $\frac{650 - t_1}{206 - 100} = 2.41$

$t_1 = 385.0$ deg. F.

Since the surface of 10,000 sq. ft. was assumed, we do not know that we have determined an economizer size that is best suited to the conditions, it becomes necessary then to assume other surfaces and determine corresponding temperature conditions. Table I has been worked out as an example and the results are plotted in curve form in Fig. 1.

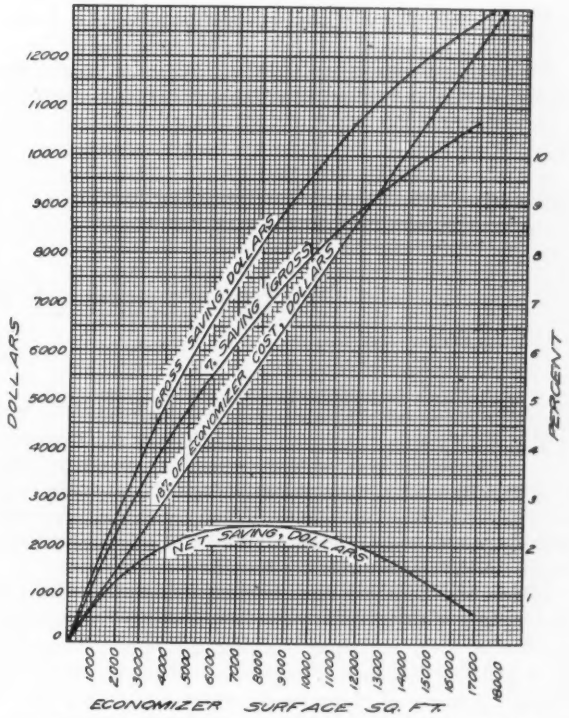


FIG. 2. RELATION BETWEEN ECONOMIZER SURFACE AND SAVINGS DUE TO ECONOMIZER

No difficulty is attached to solving for the value $10^n - 1$, even if one is not familiar with logarithms, as it is only necessary to find the logarithm equal to n and use the corresponding number, point off one decimal and subtract unity. For example, the number corresponding to logarithm 0.0188 is 1.044, then $10^n - 1 = 1.044 - 1$, or 0.044.

Having determined the gas and water conditions for various surfaces of the economizer, in order to decide whether or not it will be a good investment, or what size of economizer will be best, we must know something of the cost of the installation. Present prices will average about $4 per sq. ft. for an economizer installation, including fan, motors, etc.

It is also necessary to know how much coal the plant burns annually and at what cost without economizers, to arrive at a demonstration of the savings that may

be made. If the plant we have assumed operates on a boiler plant load factor of 40 per cent, the coal burned per year will total about 30,000 tons, and if the coal costs on an average $4 a ton, the yearly coal bill will be $120,000. The per cent saving by the economizer is given by the formula:

$$S = \frac{W_1 \times T_1 \times 100}{A \times C}$$

In which W_1 = lb. water evaporated per hr.
T_1 = temperature rise, deg. F., of the feed-water due to the economizer
A = lb. coal burned per hr.
C = B.t.u. per lb. of coal

Therefore, with the 10,000-sq. ft. economizer, the gross saving in per cent will be

$$S = \frac{138{,}000 \times 110 \times 100}{17{,}081 \times 11{,}200} = 7.93 \text{ per cent}$$

7.93 per cent of $120,000 = $9,516

A statement can now be made as follows:

Gross saving in coal, 7.93 per cent of $120,000	$9516
Deduct 18 per cent of $40,000 (economizer cost) for taxes, depreciation, interest, and operating expenses	7200
Net saving per year	$2316

Table II is worked out to show the savings for economizers under the assumed conditions, with surfaces from 0 to 17,000 sq. ft., and the results are shown graphically in Fig. 2. By examining the curve for the net savings per year, it is at once seen that the most economical installation will be about 8000 sq. ft., with a net saving per year of $2465 on an investment of $32,000 in economizers on a gross saving of $8225. By following the method given and substituting actual plant data, an accurate prediction of what an economizer installation will do, can be obtained. Some ingenuity in adapting the method to different conditions will be necessary, but anybody contemplating an economizer installation will find his time well spent in making a similar analysis.

Some Phases of the Power Situation

By E. A. Van Deusen

MODERN CIVILIZATION, in the twentieth century sense of the term, is essentially an industrial structure, and wholly dependent on those twin natural resources, raw manufacturing materials, and energy producing materials. When these two resources are abundant and are economically and efficiently developed, industrial supremacy results.

That the United States is most generously endowed by nature with all the materials necessary to modern industrial life, including stupendous power resources, is a matter of common knowledge. That the nation is using up many of these resources at a startling rate is also generally known. Moreover, these are reconstruction days, and the power resource situation has become a question of acute and vital importance, yet its actual status is a matter with which few people, even including engineers, are conversant. To picture briefly this status, particularly with respect to water-power, is the object of this paper.

There are three main sources of power in the United States, viz.: coal, petroleum and water. Coal is by far the most plentiful and the most important; petroleum is limited in supply and rapidly diminishing; water-power is plentiful, but relatively neglected and consequently wasted. These three resources will now be examined, somewhat in detail, and the status of each determined so far as it is possible.

Let us first look at coal. The latest government estimates as recorded by the United States Geological Survey in Professional Paper 100A, entitled "The Coal Fields of the United States," credit us with coal resources amounting to 4,231,352,000,000 short tons, which is 51 per cent of the total known coal deposits of the world! This figure is so stupendous as to be incomprehensible, and all it does is to create the vague impression that we have an inexhaustible supply. That it is far from being inexhaustible, however, can be shown.

The present rate of production is enormous and is rapidly increasing year by year. In the decade from 1894 to 1904 the production was 2,632,797,641 tons, while from 1904 to 1914 it was 4,779,820,431 tons, nearly twice as much. The mean annual production in the former case was 263,000,000 tons and in the latter case 478,000,000 tons. In 1914 the production was 513,525,477 tons, in 1917 it was 640,000,000 tons, and in 1918 in excess of 700,000,000 tons. The demand for power, and hence coal, is so insistent and so growing that it will be but a few years before our annual coal consumption will reach and exceed one billion tons.

All these statistics have been carefully compiled and studied by government experts; present methods of mining, marketing and using coal have been considered, and in the light of these data, estimates have been made with a view to determining the number of years our coal supply can last. The conclusions reached are that in about 50 yr. most of the high rank coal will be exhausted and that in about 100 yr. our total coal supply will be gone! The growing scarcity of coal will be felt, long before the supply is exhausted, in its steadily mounting price. Indeed, are we not already beginning to feel it?

This situation is not peculiar to the United States, but all coal countries are facing a like crisis. In this connection it may be profitable to ponder the words of the late V. B. Lewes, a distinguished English engineer and chemist who, when speaking of the coal question in England a few years ago, said:

"Among the factors that lead to the commercial supremacy of a country by far the most important is the command of fuel or other sources of power; and England's position in the past has been governed largely by her coal fields, which in a little more than a century raised her to the forefront as a commercial power. The very abundance of our coal supplies was a source of weakness, as it led to outrageous waste, polluted our

atmosphere to a criminal extent, and so encouraged uneconomical methods of using it as seriously to delete our available stock, the result of which has been the increase in price during the last few years, and the certainty that the future will see further advances but no fall to the old rates. The day of cheap coal has gone, never to return."

The growing demand for fuel and power is not confined to the United States, but is world wide. This condition will inevitably result in our being called upon to furnish coal to the less favored countries, thus will our coal production be still further increased and the day of exhaustion that much hastened. So far, our coal exports may have been relatively small, the amount for 1912 being only 20,000,000 tons and for 1913 23,000,000 tons. Doubtless these figures have been considerably augmented since 1914, on account of the terrific demands of the European countries during the war.

Let us now turn to petroleum. An illuminating analysis and discussion of this question is presented in Bulletin 102, Vol. I, of the United States National Museum, entitled "The Energy Resources of the United States: A Field for Reconstruction," by Joseph E. Pogue and Chester C. Gilbert. This bulletin is recommended to the attention of any reader who may be sufficiently interested to look further into the matter. For the present, it is sufficient to note a few of the salient points of the situation. The petroleum resources of the country are being rapidly depleted, due to enormous demands and wasteful production methods. From 1859 to 1917, a period of 58 yr., 4,200,000,000 bbl. were mined, a mean rate of 70,000,000 bbl. a year. In 1917, 340,000,000 bbl. were mined, a rate almost five times as high. It is estimated that there are now available in this country under present wasteful methods of mining, 7,000,000,000 bbl. In other words, we have a sufficient supply, based on the present increasing rate of demand, to last only about a dozen years!

Upon examination of the status of water as a means of producing power we find a very peculiar situation. Here is an inexhaustible resource—a source of power which can never give out—and which, to be conserved, must be used. Yet the federal laws governing its use were so adverse that capital held aloof, refusing to develop more than a small proportion, and thus allowing this tremendous source of power to run to waste. Coal unused is conserved, but the water that drops over our falls and flows down our rivers unused is irretrievably lost—gone forever. This state of affairs results in our deliberately throwing away the equivalent of 675,000,000 tons of coal a year. By this statement is meant that if the available water-power resources of the country were all developed, wisely and economically, and were to turn out power 10 hr. a day for 300 days a year, 675,000,000 tons of coal could be saved.

According to estimates made by the United States Geological Survey, the minimum water-power resources of the country are 28,000,000 hp. These figures, however, are based on the minimum flow of the streams. If storage reservoirs be resorted to, to equalize the irregularities of stream flow, as is usually the case, and all practicable storage sites be utilized and the water efficiently applied to the plants, then, to quote M. O. Leighton, in Water Supply Paper No. 234 of the United States Geological Survey, "There might be established eventually in the country a total power installation of at least 200,000,000 hp. and probably much more."

Recent government reports place the present water-power developments in the country at about 8,500,000 hp. No exact figures are available, and the probability is that this approximation is too high rather than too low. Thus it is seen that only a niggardly 4 per cent of our vast water-power supplies are being utilized.

Thoughtful consideration of these facts relating to coal, petroleum and water-power lead one to the conclusion that we are about to face, if we are not already facing, a serious situation. The present generation will, in all likelihood, see the exhaustion of our petroleum supplies, and coal so costly that families in moderate circumstances will be unable to buy any but the inferior grades, such as lignite. The second and third generation, our children and our children's children, may live in a coalless world.

This is a somewhat pessimistic outlook, and the question here naturally arises, can anything be done to meet

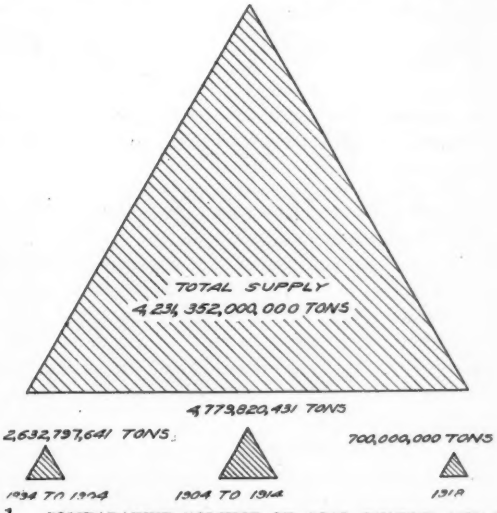


FIG. 1. COMPARATIVE VOLUME OF COAL SUPPLY AND USE. EXHAUSTION AT 1918 RATE WILL BE COMPLETE IN 7970 A. D.

this menace? Fortunately, the answer is, yes, something can be done, and in fact is being done by farseeing men, to meet the menace and defer as long as possible the inevitable day of coal exhaustion.

In general, there are three things to do, as follows:

1. Improve present methods of mining and marketing coal.
2. Electrify the railroads.
3. Develop our water-powers.

With regard to the first point, an examination of existing authoritative literature on the subject leads one to the conclusion that the coal industry is beset by conditions which lead to wastefulness. To quote a letter from the Federal Trade Commission on Anthracite and Bituminous Coal to the sixty-fifth Congress, "Wasteful methods of mining resulted in the permanent loss of millions of tons of coal that could have been saved otherwise." Chester C. Gilbert and Joseph E. Pogue in "Coal; the Resource and Its Full Utilization," (Bulletin 102, Part 4, U. S. National Museum), say: "Coal inadequately meets its obligations for three rea-

sons,—1. Competitive manner in which it is mined; 2. Unnecessary extent to which it is transported; 3. Improper way in which it is used." It is not the intention of the writer to presume to offer suggestions as to what should be done to improve conditions in the coal industry, except, perhaps, insofar as it affects railroad electrification, as will be briefly discussed, but merely to emphasize the fact that if present conditions and methods persist, our coal resources will be used up faster than they need be and should be. Any reader who may care to look further into the subject is referred to Bulletin 102, quoted above.

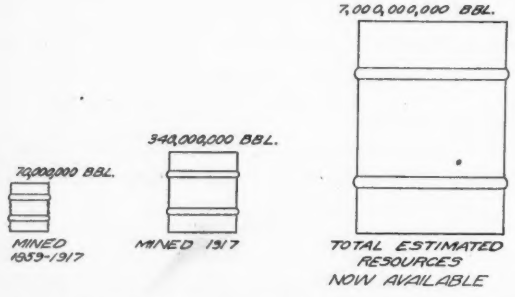


FIG. 2. PETROLEUM OUTPUT AND AVAILABLE RESOURCES. EXHAUSTION AT 1917 RATE WILL BE COMPLETE IN 1940.

The second point to be considered, the electrification of railroads, is closely allied with the problem of coal. At the annual convention of the American Institute of Electrical Engineers, held Feb. 19, 1918, the presidential address made by E. W. Rice, Jr., was entitled "Railway Electrification as a Means of Saving Fuel and Relieving Freight Congestion," and in it were many interesting points which it will pay us to consider, which are quoted herewith:

"Where electrification has been substituted for steam in the operation of railroads, fully 50 per cent increase in available capacity of existing tracks and other facilities has been demonstrated."

"It is estimated that something like 150,000,000 tons of coal were consumed by the railroads in the year 1917. Now we know from the results obtained, from such electrical operations of railroads as we already have in this country, that it would be possible to save at least two-thirds of this coal if electric locomotives were substituted for the present steam locomotives. On this basis, there would be a saving of over 100,000,000 tons of coal in one year."

This estimate is based on the assumption that the power for the electric locomotives is generated in and transmitted from central power houses using coal as fuel. It is obvious that if water-power were used, the whole 150,000,000 tons of coal could be saved.

Mr. Rice said further:

"It is really terrifying to realize that 25 per cent of the total amount of coal which we are digging from the earth each year is burned to operate our railroads, under such inefficient conditions that an average of at least 6 lb. of coal is required per horsepower hour of work performed. The same amount of coal burned in a modern central power station would produce an equivalent of three times that amount of power in the motors of an electric locomotive, even including all losses of generation and transmission from the source of power to the locomotive. Where water power may be utilized all of the coal used for steam locomotives can be saved."

Two notable examples of successful railroad electrification are those recently carried out by the Chicago, Milwaukee St. Paul R. R. and the Norfolk & Western R. R. In the case of the former 440 mi. of heavy mountain railroad between Harlowtown, Mont., and Avery, Idaho, have been electrified. The power supply is obtained from the water-power plants of the Montana Power Co., and is a striking illustration of how the natural power inherent in the mountain waterfalls can be harnessed and utilized to lift the nation's traffic

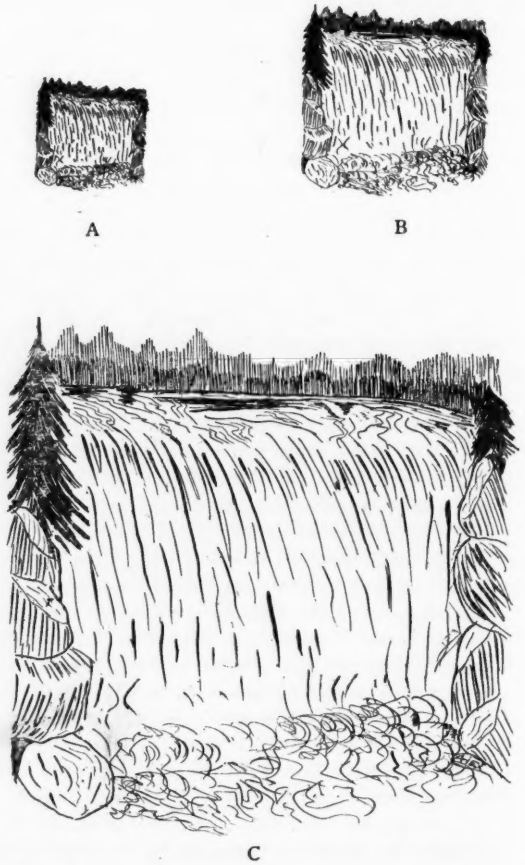


FIG. 3. WATER POWER INSTALLATION AND POSSIBILITIES. A—PRESENT UTILIZATION. B—PRESENT RESOURCES. C—RESOURCES AVAILABLE WITH RESERVOIRS AND FORESTS. TIME OF EXHAUSTION AT HIGHEST RATE IS INFINITY

across the mountain ranges, thus saving or releasing for other purposes hundreds of thousands of tons of coal every year. In the case of the Norfolk & Western R. R. power is supplied from large central steam power stations located at the mine heads in West Virginia. As

mentioned before, this method of generating the necessary power for moving traffic is approximately three times as efficient, as far as coal consumption is concerned, as in the case of steam locomotives. It is evident, therefore, that here is another example in which a large annual saving of coal is effected.

It must be noted, however, that railroad electrification, though most desirable from the point of view of the conservation of our fuel resources, is a matter that cannot be undertaken wholesale, for several reasons. In the first place, the capital outlay necessary would be enormous, and would run well into billions of dollars; and in the second place, each individual railroad system, or even division, is a problem in itself, to be judged on its own merits. It is safe to say that in the majority of cases electrification would be economically unsound at the present time. Nevertheless, electrification is inevitable; but it will not come through wholesale and revolutionary methods, instead, it is to be hoped, in accordance with the dictates of sound judgment based on ripe experience and a knowledge of the workings of economic and engineering laws.

The third point that needs our attention, in the interests of power resource conservation and utilization, is water-power development. In some respects, this is the most important of the three points: first, because the development of our water powers is the most logical and simple step to take; and second, because, as previously mentioned, non-usage of this inexhaustible source of power represents the deliberate throwing away of millions of tons of coal per year.

Of the 200,000,000 potential water horsepower in the country, government records indicate that over 70 per cent are located in the Mountain and Pacific States, that is to say, in the Public Land States. Under the past federal laws, the would-be developer of water-power on these lands could not obtain a title which could be used as a basis for credit. This state of affairs has resulted in the virtual stagnation of the water-power industry. The question of remedying this condition has been before Congress for the past 10 years, but, until recently all efforts to obtain relief have been fruitless; however, a bill, known as the Water-Power Bill, which aims to release these water powers for development, and at the same time protect the people's interests, has recently been passed by Congress.

The water powers of the country have been developed to a very satisfactory extent in some sections, particularly where located on rivers and streams unaffected by the restrictive federal laws. For instance, in the New England states approximately 600,000 hp. have been developed and are in use and yearly produce about 2,000,000,000 kw.-hr., the equivalent of 3,000,000 tons of coal. Again, a prominent water-power company in the South in 1917 produced the equivalent of 900,000 tons of coal, while the equivalent output of a middle west company annually amounts to about 300,000 tons. Many other instances might be cited, but these three should serve to indicate what is being done under adverse statutory conditions and suggests how much more might be done under more favorable legislation.

No more fitting conclusion to these remarks on the menacing condition of the present power situation could be found than the following words written by George Otis Smith, Director United States Geological Survey, in 1916:

"Our unsurpassed coal reserves, reinforced by these water-power resources, constitute a strong line of national defense in that they form a real basis of an industrial organization of the nation's workers. It is only through abundant and well distributed power that the other material resources of the country can be put to their highest use and made to count most in the nation's development."

Yes-ing the Boss

YES-ING the Boss is a great indoor sport—agreeing with him in everything that he proposes or suggests, says Clifford A. Sloan in Forbes Magazine.

"Two weeks ago, on a train from Chicago, I met a man of big business, a vice-president of a big corporation, and he told me that his hardest job was to get men who were big enough, who had backbone enough, to disagree with the Boss, men who had opinions of their own and ideas of their own, and who were not afraid to express these opinions and ideas.

"There are two classes of men who yes the Boss. The first is the peanut-brained fellow without a single idea. Naturally, all he can say is 'Yes.' The second is the chap who has ideas of his own, but he lets them stay inside—too afraid to express them. Then there are two kinds of men who do not yes the boss. The first is the pin-headed fellow who cannot see any suggestion except his own. The second is the chap who has ideas, who is not afraid to suggest them, but who is big enough to admit that the other fellow's plan is better and then to get behind the big idea.

"If you've an idea to offer, a plan to suggest whereby this or that work can be done more effectively, offer it! The Boss cannot know the detail work of every department and of every desk. He wants you to study your work, to improve it, no matter how unimportant your job may seem to you. He wants ideas from you. But if a better plan than yours is suggested, be broad-minded, admit it and get behind the Big Idea.

"Failure to make suggestions is not helping the Boss. Agreeing with him in everything he suggests is not helping him.

"Nor is it grooming yourself for a bigger job and bigger responsibilities."

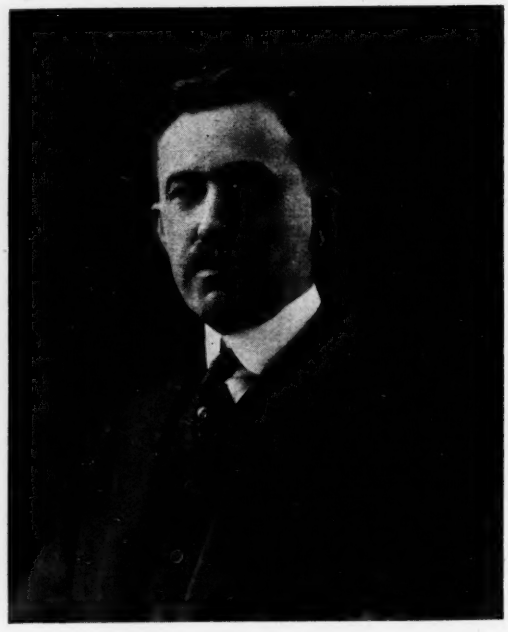
U. S. CIVIL SERVICE COMMISSION announces examinations, April 7, 8 and 9, May 5, 6 and 7, and June 9, 10 and 11, for assistant examiner, Patent Office, to fill vacancies in the Patent Office, Washington, D. C., at the entrance salary of $1500 a year, with temporary increase granted by Congress of $240 a year, to appointees who perform satisfactory service, and vacancies in positions requiring similar qualifications. Competitors will be examined in French or German, mechanical drawings, and technics, covering the general field of mechanics, mechanic arts, industrial arts and processes, and applied chemistry, and one other subject to be selected from a list of optional subjects. Apply for Form 1312.

HEAT will draw temper. Example: a hot bearing will cause an engineer to lose his temper.

PETER JUNKERSFELD

BEGAN AS HELPER AT THE HARRISON ST. STATION OF CHICAGO EDISON CO.—AT 15 CENTS AN HOUR. INSTALLED FIRST 25-CYCLE SYSTEM, AND WAS ACTIVE IN DEVELOPING LARGE CHICAGO POWER PLANTS. BY ERNEST S. BUTT

THAT the country boy, plus the advantage of a college education, is better fitted to climb the ladder of success than his urban cousin under the same conditions, is a rather popular theory. When the advantages of education are given him, his mind is open and receptive and able to grasp the route to the top more readily than if he had spent his adolescence in the blase surroundings of the big city.



Peter Junkersfeld was born near the little town—it might almost be called village—of Sadorus, Illinois. His early life was spent in the typical country manner; hard work during the summer time and a session at the neighboring school after "corn huskin'." By and by, he entered the University of Illinois at Urbana with his mind on an engineer's degree. After four years in the University he was graduated in 1895. Then the big city called him.

At that time, the biggest central station in the world was the Harrison Street station of the Chicago Edison Co. It was the last word in central station construction, the goal of all the budding electrical engineers west of the Alleghenies. So it was but natural that Peter Junkersfeld, aged 26, should look upon it as the jumping off place in his professional career; and right there, in October, 1895, was born a professional connection that lasted nearly 24 years.

After his name had been placed upon the payroll, they wrote "helper" after it, and followed that significant title with "fifteen cents an hour." The work was all that the title implied, for in those days a helper was a helper and not an assistant. But work never daunted Junkersfeld, for, to use a time-worn phrase, he was a "glutton for work." And to the knowledge of the chronicler that appetite has never been quite satiated.

Two years of this sort of apprenticeship, and the company found that they needed just this sort of "helper" in the Engineering Department as a draftsman. One year of this and he was given the title of Chief Draftsman, and in another year that of Assistant to the Mechanical Engineer. Here he began to find himself, for his ability, recognized by his superiors after putting into service the first 25-cycle system, consisting of a 250-kw. inverted rotary supplying energy for two 100-kw. rotaries at one of the company's substations, got him the task of installing the first engine-driven 25-cycle double current units in America.

He was also given charge of the installation of the initial set of large storage batteries at the old Adams Street substation and, after that, additional boilers, engines, and generators at the old Washington Street station.

About this time, the young man had sounded himself, and the company, recognizing this, gave him direct charge of the design and construction of all the 25-cycle generating units and the connected transmission and substation system at the Harrison Street station, and a similar task at the 56th Street station. Later he took an important part in the development of Fisk, Quarry, Northwest and other stations and substations. In 1903, he made an investigation and report on physical consolidation of five distributing systems in St. Louis, which report was accepted and resulted in a modern and comprehensive system of electricity distribution for that city.

His activity in connection with supplying railroads with power, which began with the Chicago Edison Co.'s first contract for power supply to railroads, marked another step in his career. This energy went to the Lake Street Elevated in 1901, the contract calling for about 1000 kw.

Then the next step! In 1906, Junkersfeld made an

investigation of the electric power requirements necessary to have all steam passenger trains hauled a distance of 25 miles from Chicago terminals. His report was also used as a thesis by his Alma Mater, the University of Illinois, for which he was granted a post-graduate professional degree of Electrical Engineer in 1907.

During this period, the fortunes of Peter Junkersfeld had advanced. From 1906 to 1909 he was Electrical Engineer. During the latter year, he was appointed assistant to the vice-president in charge of the Operating, Contract, Construction and Electrical Departments. In the following eight years, he had a wide experience as a public utility executive in addition to continued experience in power supply and power plant engineering.

All this time, in spite of the demands upon him to supervise this and erect that, Junkersfeld did not forget that he was part of a big organization, and as such expected to contribute to its advance. This he did by interesting himself in matters calculated to augment the already cordial relation between the company and its customers and employes. As chairman of the sub-committee appointed for the purpose, he was largely instrumental in developing a savings fund and annuity system, arrangements that permit an employe to obtain company stock at par by saving a definite portion of his salary (savings on which he is paid a high rate of interest), and retires an employe on a pension when he or she has reached a prescribed age and has served the company for a certain length of time. He was also instrumental in the inception of the Safety Committee, an organization that has done much to inculcate safety methods in the minds of company employes.

After Germany plunged Europe into a maelstrom, our country took an account of itself and decided that an Officers Reserve Force was needed. Leaders in every branch of American industry were placed upon the reserve list in case anything happened. In June, 1917, Peter Junkersfeld, as one of five leaders in the engineering and construction field placed on the reserve list in February, 1917, was called into active service with the rank of Major of Engineers. Early in June, 1917, he commenced supervising the construction work of the Construction Division of the Army.

It was here that Junkersfeld proved that he had capacity for work, for his particular task was "directing the constructing forces in the field and advising and directing the commercial relations of the Construction Division of the Army." The work itself involved tremendous responsibilities. The Major had to be on the job all the time. He traveled over a large part of the United States from coast to coast, from the Canadian border to the Gulf of Mexico. Truly a job of work.

In general, Major Junkersfeld was the general organizer of the working forces in the field; he made a careful survey of the conditions and of the construction work connected with each project, including the installation of water works, sewers, roads, railroad tracks, electric power and light, the erection of barracks and various other buildings, and the provision for adequate transportation and care for men and materials. He dealt with masters of transportation, engineers, general contractors, and producers of all kinds of construction material and equipment.

The amount of detail handled was so enormous and the time available so short that the Major and everyone else had to keep going every day and nearly every night without intermission.

By September 15, 1917, only three months after work was started, 16 cantonments and 16 camps for the first quota of the new National Army were ready. The supplies for this army required so many facilities of every conceivable character, due to the unpreparedness of our country, that on Nov. 11, 1918, more than 400 different projects were under construction and over $800,000,000 worth of construction work had been done.

In recognition of the Colonel's efforts during the war period, he was promoted twice early in 1918 from Major to Lieutenant-Colonel and from Lieutenant-Colonel to Colonel. He was discharged as Colonel on March 4, 1919, with the knowledge of work well done and the objective attained—the decisive defeat of Prussianism.

Of course, Colonel Junkersfeld always was a bred-in-the-bone Edison man, but that didn't prevent him from taking quite an extensive interest in his chosen profession. He served for two years as President of the Association of Edison Illuminating Companies; three years as Vice-President of the American Institute of Electrical Engineers; and he is a member of the American Society of Mechanical Engineers, the Western Society of Engineers, the National Electric Light Association and the American Electric Railway Association. His connections other than as a public utility executive have been the Chicago Electric Meter Co., the Minerallac Co. and the Geyser Electric Co. At different times in his various capacities he has contributed valuable reports and papers to the literature of the industry.

Colonel Junkersfeld returned to the Commonwealth Edison Co. early in March, 1919, but on April 1 he went to Boston as Engineering Manager for Stone and Webster.

It has been well said that men who steadfastly stick to their guns and play the game will ultimately reap their reward, reward that may, at the outset, seem unattainable. That is true, and the harder the fight the sweeter the harvest of success.

A Spring Tonic

WHEN SEATED in a theater, we often get tired of a certain performer's work, but stick it out hoping that the next one will suit us better.

Now, old Jack Frost will soon make his exit, and Miss Springtime will endeavor to amuse us. Let's meet her with a plentitude of smiles and hopes. If that is done, we shall pave the way so that her efforts will be received with a happy mien, and possibly her entire act will be of the rejuvenating kind.

There's an old saying which tells us that if we spend the first hour of the morning in a contented frame of mind, we may depend upon the entire day proving to be a pleasant one.

WALL STREET JOURNAL states that production of oil in Oklahoma and Kansas showed a decrease of 33,000,000 bbl. in 1919 from the preceding year.

Steam Used in Textile Processes*

ECONOMY IN THE USE OF STEAM COULD BE IMPROVED IN MANY PLANTS. USE OF HEAT IN THE VARIOUS PROCESSES. BY GEORGE H. PERKINS

THE collective textile industries of the United States consume 9,662,600 tons of coal annually, and require for their operation a total primary power of 2,495,000 hp., of which 66.8 per cent, or 1,665,900 hp., is developed by steam prime movers.

Tables I and II give figures compiled from the United States Census of Manufacturers for 1914, showing the distribution of coal and primary power to the seven principal manufacturing groups included in the textile industry. These figures serve to emphasize the magnitude of the steam requirements of this industry, which are to be considered in this paper, with particular reference to the heat demands of textile processes.

The relative fuel economy of the different textile groups has been derived from the above data and is given in Table III, where the listing is in order of comparative performance, as figured on a common basis of power production. The results show clearly the effect of extensive steam use in processes on the over-all economy.

The cotton goods and cordage groups rank first, owing to their small demands for process steam, the relatively good economy, general utilization of exhaust steam in processes, and the better balance usually existing between the steam demands of prime movers and processes.

TABLE I. COAL CONSUMPTION AND STEAM-POWER REQUIREMENTS OF THE TEXTILE INDUSTRIES

Industry	Anthracite, 1000 Tons of 2240 lb.	Per Cent of Total Anthracite	Bituminous, 1000 Tons of 2000 lb.	Per Cent of Total Bituminous	Steam Power, 1000 Hp.	Per Cent of Total Steam Power
Carpets and Rugs	74.7	3.1	193.7	2.7	29.5	1.8
Cordage, Jute Twine and Linen	91.9	3.8	195.2	2.7	65.8	4.0
Cotton Goods	313.5	13.0	3634.2	50.0	1011.3	60.7
Dyeing and Finishing*	490.6	20.5	896.6	12.4	111.5	6.6
Hosiery and Knit Goods	118.1	4.9	484.3	6.7	80.8	4.9
Silk Goods	1053.7	44.0	249.9	3.5	78.3	4.7
Woolen, Worsted and Felt	257.4	10.7	1608.8	22.0	288.7	17.3
Total	2399.9	100.0	7262.7	100.0	1665.9	100.0

*Exclusive of that done in textile mills.
Fuels other than coal have been omitted as the equivalent total is small.

The dyeing and finishing group have a comparatively small power demand and a most extensive use for process steam. The relation of coal to power in the silk goods group appears out of proportion in comparison with the other industries and must be attributed, in part, to wasteful steam use and a more extensive use of the lower grades of fuel.

The validity of the results given in Table III may best be shown by citing a number of specific examples of different types of plant, giving the actual fuel consumption and power production. This is shown in Table IV. These figures check well with the average for the respective groups as given in Table III.

It is still the practice in many textile plants to compare the total weight of coal burned with the weight or yardage of goods processed or produced. Such ratios are at best only rough measures of the actual economy and are subject to wide variations, with fluctuations in the quantity or quality of the product, grade of coal, etc. As a matter of interest only, the following gives

TABLE II. DISTRIBUTION OF PRIMARY POWER IN THE TEXTILE INDUSTRIES

Industry	Total Primary, 1000 Hp.	Steam Power, 1000 Hp.	Water Power, 1000 Hp.	Internal-Combustion Engines, 1000 Hp.	Rented Power	
					Electric, 1000 Hp.	Other, 1000 Hp.
Carpets and Rugs	44.0	29.5	4.1	...	9.2	1.2
Cordage, Jute Twine and Linen	93.0	65.8	14.4	2.8	10.7	0.2
Cotton Goods	1585.9	1011.3	314.2	4.0	252.9	3.5
Dyeing and Finishing	130.1	111.5	9.9	0.7	7.2	0.8
Hosiery and Knit Goods	125.7	80.8	14.6	1.1	26.3	2.9
Silk Goods	117.0	78.3	7.6	1.8	23.8	5.5
Woolen, Worsted and Felt	398.4	288.7	76.3	2.7	25.0	5.7
Total	2495.0	1665.9	441.1	13.1	355.1	19.8
Per Cent of Total	100.0	66.8	17.7	0.5	14.2	0.8

the average range of these ratios for a number of the industries:

Industry—	Coal per unit product
Cotton goods	2 to 2.25 lb. per lb. of cloth produced
Jute goods	1 to 1.25 lb. per lb. product
Woolen goods	6 to 7 lb. per lb. of cloth finished
Worsted yarns	3 to 3.25 lb. per lb. of yarn produced
Wool scouring and combing	0.8 to 1.2 lb. per lb. of grease wool processed.
Bleaching and finishing	0.8 to 1.3 lb. per lb. goods processed
Print works	2.5 to 3 lb. per lb. of goods processed

The approximate proportion of the total coal which is used by processes in this industry is given in Table V.

These figures are based on data obtained from the analysis of representative plants. While the requirements of individual mills in the same group will vary according to local conditions, it is believed that the figures presented are conservative and will serve the present purposes.

IMPORTANCE OF HEAT APPLICATIONS

THE FOREGOING facts emphasize in general terms the importance of the problems of heat application to textile processes. These problems fully warrant far more technical attention than they have yet received, both from the standpoint of production efficiency as well as for fuel economy; but little progress has been made along either line, in comparison with the marked advances in the art of generating steam and power.

Many textile power plants are "saving at the spigot and wasting at the bung," and the average dye-house, bleachery or print-works is usually considered a necessary evil, to be endured up to the limit of the plant's boiler capacity. While production efficiency must be considered as of the first importance, the present fuel

* From a paper read before the annual meeting of the American Society of Mechanical Engineers, New York, December, 1919.

situation demands rigid conservation in the use of both coal and steam.

The purposes for which heat is applied to textile materials in process are numerous and varied, and only the principal ones will be summarized as follows:

Process—	Material—	Purpose or effect of heat—
Scouring	Wool	To assist the action of the soap and alkali
Carbonizing	Wools and shoddies	To free the acid from moisture to permit carbonization
Combing	Worsted wools	To facilitate drawing through the pins
Dyeing	All materials	To assist the fixation of dyestuffs
Kier boiling	Cotton goods	To assist action of liquor in softening impurities
Drying	All materials	Evaporation and removal of moisture
Tentering	Cotton and worsted goods	To dry goods under tension retaining width
Steaming	Woolen, worsted and print goods	To shrink, remove glaze and to set fabrics and colors
Soaping	Print and dyed goods	Warm water removes surplus color and improves appearance
Aging	Print and dyed goods	To set or develop colors
Washing	Woolen and worsted goods	Warm water removes oil and soap applied in previous processes
Pressing	Woolen and worsted goods	With pressure, flattens surface for finish effect
Calendering	Cotton goods	With pressure and friction assists in producing lustre

TABLE III. COMPARATIVE FUEL ECONOMY OF THE TEXTILE INDUSTRIES

Industry	Equivalent Bituminous 1000 Tons of 2000 lb.[1]	Per Cent of Total	Steam Power 1000 Hp.	Per Cent of Total Primary Power	Tons Per Hp. Per Year	Lb. Per Hp. Per Hr[2]
Cotton Goods	3947.7	40.8	1011.3	63.7	3.90	3.12
Cordage, Jute, Twine and Linen	287.1	3.0	65.8	70.0	4.35	3.48
Woolen, Worsted and Felt	1866.2	19.3	288.7	72.3	6.50	5.20
Hosiery and Knit Goods	602.4	6.2	80.8	64.5	7.45	5.96
Carpets and Rugs	268.4	2.8	29.5	67.2	9.08	7.26
Dyeing and Finishing	1387.2	14.4	111.5	85.8	12.50	10.00
Silk Goods	1303.6	13.5	78.3	67.0	16.70	13.36
Total	9662.6	100.0	1665.9	66.8	5.80	4.64

[1] Anthracite ton of 2240 lb. included as equivalent of Bituminous ton of 2000 lb.
[2] Based on 2500 hr. operation per year.

Classification of Principal Heat-Using Processes

Application—	Machines of similar use—
Direct contact of materials with steam or water vapor	Steamers for woolen goods, print goods, etc. Aging machines for print and dyed goods. Yarn conditioning machines
Direct contact of materials with heated surfaces for warming stock, pressing, polishing, drying, etc.	Worsted comb steam chests Worsted back washers Plate presses for woolen goods Rotary presses for woolen goods Slashers and dressers Cylinder and can dryers Calenders for cotton goods Polishers for twine, thread, etc.
Drying of materials with air heated by direct or indirect radiation	Hot air slashers and dressers Cotton and wool stock dryers Carbonizing dryers Cloth dryers Shrinking dryers Tenter frames Dry rooms for yarn Back washer dryers
Direct use of steam for boiling or heating liquids and use of warm water	Dye tubs and dyeing machines Scouring bowls for wool Bleaching kiers Cloth washers. Crabbing machines Starch and size cooking Soapers
Indirect use of steam for heating liquid	Bleaching kiers with closed heaters and circulating pumps Jacketed kettles for size, starch or dye-stuffs Tubs and dyeing machines with closed submerged coils Preheating of liquids for process or storage by closed heaters

The direct or indirect heating of rooms containing processes requires careful temperature and humidity control.

Factors Affecting Production and Economy

Some of the various conditions commonly found, which affect either production or economy, are as follows:

Production—	Economy—
Wet steam	Leakage from traps, vents, etc.
Poorly designed steam distribution system	Wasted drips
Incorrect arrangement of traps	Overheating or over cooling through careless operation
Deficient trap capacity	Radiation losses through dryer housings, etc.
Delays in heating liquor, dyes, etc.	Waste of exhaust steam or condensing water
Inefficient air circulation in dryers	Lack of hot water storage
Deficient dryer radiation	Failure to recirculate air in dryers

TABLE IV. ACTUAL ECONOMY OF INDIVIDUAL PLANTS

Kind of Plant	Total Coal Tons	Total Steam Power Hp.	Coal Per Hp. Per Year
Cotton goods, no dyeing	10,500	2,800	3.75
Cotton goods, with dyeing	13,000	3,000	4.33
Jute goods	9,400	2,200	4.28
Worsted yarns	1,560	340	4.6
Woolen goods	1,800	270	6.67
Bleachery and finishing	10,200	800	12.75
Print works	60,000	4,000	15.00

In addition to the foregoing, there is usually little information available, either of the steam requirements or demands. While considerable progress is being made in means and methods of correcting the conditions mentioned, there is still room for much improvement.

Many of the larger mills are making complete steam surveys of their plants periodically, to check use against demand and also to enable steam costs to be properly apportioned to the various processes. Modern steam meters give reliable results and invariably reveal many surprising conditions which require attention and which cannot be disclosed by any other means.

TABLE V. CLOTH DRYER TESTS

	Uninsulated Housing Woolen suiting	J-M No. 1 Type Insulated Housing Woolen suiting
Weight of goods, oz. per yd	13	13
Weight of wet goods processed per hr., lb.	900	1047
Weight of goods dried per hr., lb.	523	609
Yards dried per hr., lb.	644	747
Weight of water evaporated per hr., lb.	377	438
Per cent moisture in wet cloth	41.9	41.9
Heating surface, sq. ft.	2240	2240
Steam pressure, gage	42.5	43.5
Temperature in dryer	135 deg. fahr.	189 deg. fahr.
Weight of steam condensed per hr., lb.	875	748
Steam condensed per sq. ft. of radiation	0.39	0.33
Steam per lb. of dry cloth, lb.	1.67	1.21
Steam per lb. of moisture evaporated	2.32	1.85
Yards dried per lb. of steam	0.735	1.01

The results of tests made at different plants are given in Figs. 1 and 2, and in tables, merely to illustrate common practice and not as standards of high performance. They will, however, be found useful for comparative purposes.

The following suggestions are offered as concrete lines for useful and practical study and research:

(a) Further investigation of conditions of temperature, humidity and air circulation for drying various materials with maximum production and minimum heat consumption.

(b) Development of more efficient arrangement of radiation and air circulation in dryers.

(c) Automatic control of the production rate of dryers, through conditions resulting from drying results obtained.

(d) Further development and application of temperature control devices to heat using processes.

(e) More effective utilization of exhaust steam in processes, heating water storage, etc.

(f) Recovery of heat from spent and rejected liquors.

(g) Development of insulating materials to be used under conditions where equipment is subject to extreme moisture conditions or to mechanical injury.

(h) Use of supplementary air circulation with can dryers.

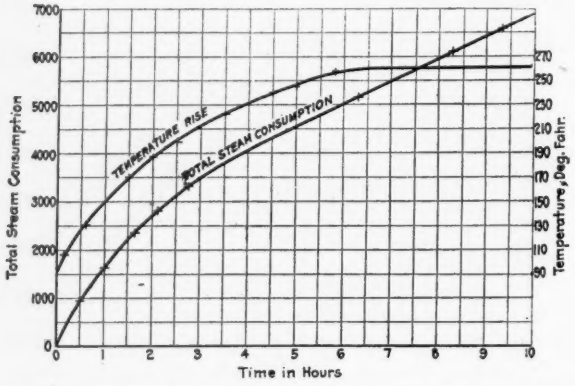


FIG. 1. TEMPERATURE RISE AND STEAM CONSUMPTION IN KIER TEST

The field is a broad one, with many varied and complex problems, but the co-operative effort of manufacturers, machine builders and engineers should bring about much needed improvement in the present average practice.

Steaming Value of Alaska Lignite

THE FAIRBANKS, Alaska, Station of the Bureau of Mines, has recently completed two series of tests designed to determine, first, the comparative steaming value of Alaska lignite and spruce wood, and second, the resistance of lignite to weathering when stored in piles in the open. The tests were made under the direction of John A. Davis, superintendent of the station, who was assisted by Paul Hopkins and John Gross.

The steaming tests were run to determine the relative value of lignite and spruce wood in the small boilers commonly used in the mining camps of Alaska. Spruce wood has been used for steaming purposes almost exclusively in the past, but the price has risen from $7 to $20 per cord in the last 15 yr. and other sources of fuel are sought. The lignite used in the tests was not of the highest quality, since it was obtained near the surface. Both the wood and the lignite were carefully weighed, sampled, and analyzed, so that the results of the tests could be accurately compared. The boiler used was one of a battery of two horizontal water-tube boilers, each rated at 125 b.-hp. Two grades of lignite, one from the Lynn mine and one from the Burns mine, and one grade of wood were tested.

The results showed that, under the conditions of these tests, when compared pound for pound the value of spruce wood lay between the values of the two samples of lignite. The relative water evaporations per pound of fuel were: Lynn lignite, 3.06; Burns lignite, 3.99; spruce wood, 3.68 lb. However, in comparing a cord of wood with a ton of lignite, it was shown that a cord of wood is equivalent to more than a ton of lignite from either mine.

In the weathering test, several hundred pounds of Nenana lignite were used. It was first carefully sampled for analysis and then sized through a series of rings from ⅜ in. to 2 in. in diameter, 80 per cent of the sample being retained on a 1-in. ring. The lignite was then spread in shallow trays and placed on the roof of the station, where it was allowed to remain, fully exposed to the weather, for 14 mo. At the end of a week it was noticeably weathered on the surface, and at the end of a month it had broken up into small pieces.

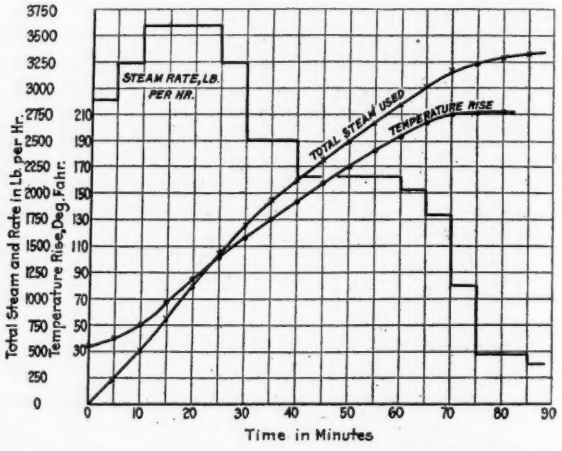

Total Steam and Rate in Lb. per Hr.
Temperature Rise, Deg. Fahr.
Time in Minutes
STEAM RATE, LB. PER HR.
TOTAL STEAM USED
TEMPERATURE RISE

FIG. 2. TEMPERATURE RISE AND STEAM CONSUMPTION IN DYE-TUBE TEST

At the end of the test period, it was found that the surface portion, immediately exposed to the atmosphere, was entirely disintegrated, while that farthest from the surface was only partly disintegrated, although very fragile. Over 50 per cent would then pass through a ⅜-in. ring and 85 per cent passed a ¾-in. ring. The average loss in weight through weathering was 6.08 per cent (mostly moisture). The weathering at the end of 14 months, however, seemed only slightly more than that at the end of one month. In large piles only the surface, to a depth of 4 in. to 6 in., would weather badly and the material beneath would be so protected as to suffer little change. These tests show that the behavior of these lignites is substantially the same as that of North Dakota lignite.—Bureau of Mines, Monthly Reports of Investigations.

U. S. CIVIL SERVICE COMMISSION announces an examination, April 20, for expert designer, to fill a vacancy in the Engineer Department at Large, Florence, Ala., at $4200 a year, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries. Competitors will be rated on education and experience. Apply for Form 1312.

Graphic Records of Flue Gas Analyses

Records of CO_2 and O_2 Show Definitely Causes of Combustion Losses. By F. D. Harger

THE article "Reading Chimney Losses Direct from CO_2 Charts," by C. C. Phelps, in the Jan. 15 issue of Power Plant Engineering is illuminating and gives a good understanding of this subject to the reader.

The article says that the percentage of CO_2 serves as an ideal guide to determine the air excess, for the reason that the percentage of CO_2 varies inversely as the percentage of excess air. How true this statement is will be observed by a glance at the two charts, Fig. 1.

The lower chart shows the percentage of CO_2, while the upper chart shows the percentage of oxygen of a gas sample taken and continuously analyzed and recorded. The records were taken simultaneously with the same instrument.

When cutting out the two charts and laying the

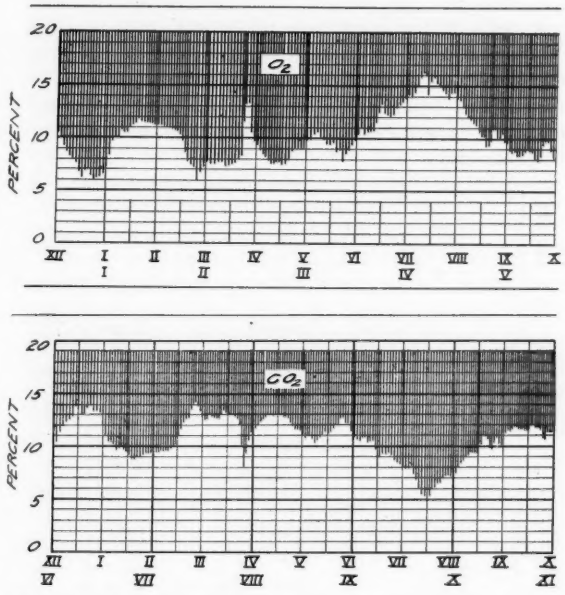


FIG. 1. CONTINUOUS RECORDS OF CO_2 AND O_2 TAKEN SIMULTANEOUSLY

oxygen chart upon the CO_2 chart, face to face, i.e., ink to ink, being careful that the hours also face each other, as has been done in Fig. 2, it will be found that one is pretty nearly a reflection of the other. At least a very definite relationship is established. Assuming that no combustible gases were produced, the CO_2 reading plus the O_2 reading would be 21 per cent, which is the sum of carbon dioxide, carbon monoxide and oxygen. If, however, some small percentages of carbon monoxide are formed, this will be indicated by the fact that the sum of CO_2 and O_2 is short of 21 per cent total, this difference representing the amount of combustible gases $(CO + CH_4)$ produced in the sample taken and analyzed.

It would, therefore, appear that with the highest amount of CO_2 and a reasonably low exit temperature of the gases maximum furnace efficiency would be obtained. This is, however, not necessarily so and, if criticism be permitted, nothing is said in Mr. Phelps' article concerning the formation of combustible gases $(CO + CH_4)$ which will usually set in as soon as the percentage of carbon dioxide reaches a certain high amount.

A chart shown in Fig. 3 will make this assertion entirely clear. The upper curve shows the percentage of CO_2, while the lower one shows the percentage of $(CO + CH_4)$ in a gas sample—i.e., the combustible

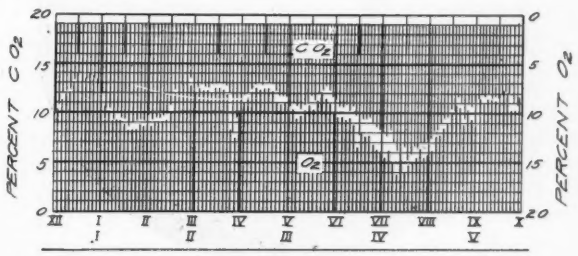


FIG. 2. RECORDS OF CO_2 AND O_2 TURNED FACE TO FACE

gases. It will readily be noted that even with 12 per cent CO_2 combustible gases are present in this particular instance, and it is therefore evident that a certain "safety zone" exists for each boiler furnace under certain load conditions; that is to say, under no condition should the percentage of CO_2 be allowed to build up to anything higher than about 12 per cent, depending, of course, upon the type of boiler, nature of fuel, load, etc.

Combustible gases may be formed with a low per cent of CO_2, as would be the case if an incandescent firebed were covered with a large quantity of green coal. This would, of course, indicate an insufficiency of air,

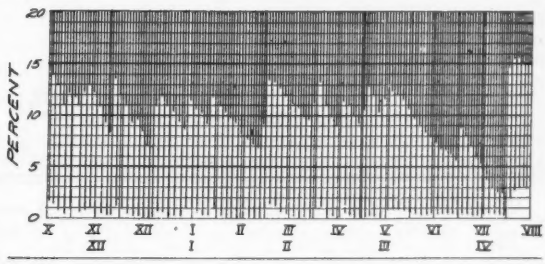


FIG. 3. COMPOUND RECORD OF PER CENT CO_2 AND COMBUSTIBLE IN FLUE GAS

which is just as wasteful as to permit formation of combustible gas with a high per cent of CO_2. The point is this, find the safety zone for your particular case and remain well within it. Thus due warning is given that operating with a high per cent of CO_2, as is so commonly practiced, is frequently a very wasteful course to pursue.

Below is given a table published here for the first time showing not only the free losses of heat up the chimney, but also the latent losses of heat due to incomplete combustion. Assuming that there is only one per cent of carbon monoxide and one per cent of hydro-

carbon (CH_4), it will readily be seen that, for instance, with 10 per cent of CO_2 the fuel losses are 20 per cent, to which must be added the loss due to the combustible gases as cited, of 21 per cent, thus giving a grand total of 41 per cent of the total heating value of a given kind

FIG. 5. FLUE GAS LOSS CALCULATOR

of coal. These losses are appalling, and one wonders why the importance of recording instruments for CO_2 and combustible gases ($CO + CH_4$) is so little recognized by power plant owners.

At a temperature of 572 deg. F. the percentage of carbon dioxide in the flue gases of... corresponds to	6	7	8	9	10	11	12	13	14	15	16	%
a loss of fuel in percentage of the total calorific value due to the temperature of the flue gases (free loss of heat) of..	33	28	24	22	20	18	16	15	14	13	12	%
a loss of fuel in percentage of the total calorific value due to incomplete combustion (latent loss of heat) if the flue gases contain, for instance, 1 per cent carbon monoxide (CO) and 1 per cent hydrocarbon (CH_4) of.....	32	28	25	23	21	19	18	17	16	15	14	%
Total amount of the free and latent losses of heat under above conditions.....	65	56	49	45	41	37	34	32	30	28	26	%

What Mr. Phelps says about a "flat record" is very correct. A CO_2 chart as shown above in Fig. 4 will average up very nicely indeed. Supposing a gas collector had been employed to take that sample. What a fine sample it would have been—and how misleading would have been the satisfaction!

The above chart was taken from a hand-fired boiler, Scotch marine stationary type and shows that fires were coaled up about 4 to 5 times an hour. After a little investigation, the firing periods were increased to about 10 an hour in this instance and the fuel amount at every firing period considerably decreased, resulting in a flatter record, averaging about 12½ per cent and considerable economy. (Here is another proof of the advantage of the mechanical stoked over the hand-fired furnace.)

Mr. Phelps shows a special scale he has worked out in an ingenious manner. Such might be made of celluloid or other transparent material; however, the only fault with this scale is that it can be used only with Uehling charts, while the little slide rule shown here is adaptable for all methods of gas analysis, recording or Orsat. The readings nearest the center represent the per cent of CO_2 found. This whole center is revolved

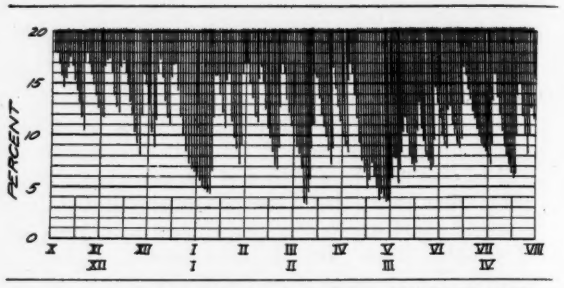


FIG. 4. CO_2 RECORD OF A HAND-FIRED FURNACE WITH INFREQUENT FIRING

and each per cent of CO_2 can thus be set opposite the row next to the inner row of figures, representing the temperature (T—t). A little indicator points then to the third row of figures from the center and also to the fourth row from which are read the heat losses up the chimney and their corresponding heating value, respectively.

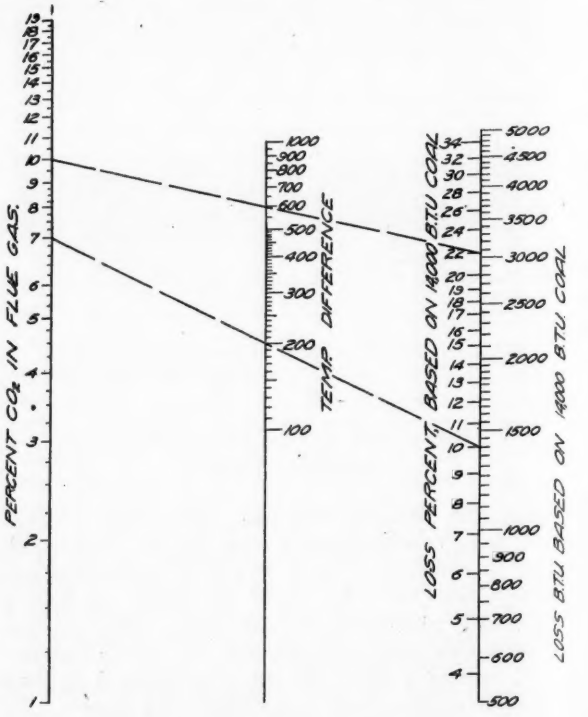
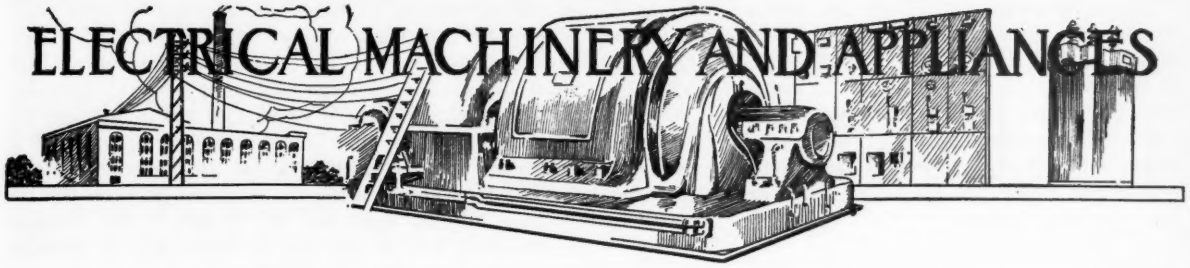


FIG. 6. ALINEMENT CHART FOR CALCULATING FLUE GAS LOSSES

As an example and as shown in Fig. 5, the CO_2 percentage is 9½ per cent of the temperature is 500 deg. F. Set CO_2 opposite 500, then the indicator points down to 19 per cent, representing the free losses of heat, and up to 2660, representing the loss expressed in heat units.



A Study of Dynamo Electric Machinery---XIII

THE STATIC TRANSFORMER; ITS THEORY OF OPERATION AND CONSTRUCTION. BY OTTOMAR H. HENSCHEL

IN ORDER to understand the workings of the static transformer, it is necessary first to have a clear conception of the theory of electromagnetic induction, for it is upon this that operation of the transformer is based. The laminated iron structure shown in Fig. 87 has wound upon two legs of it coils of insulated magnet wire one of which connects through the medium of a reversing switch to a source of direct current, in this case a battery, while the other connects to a differential low-reading voltmeter; that is, a voltmeter with zero graduated at the center of the scale and higher reading to the right and left of this. The direction of deflection of the needle depends upon the direction of current flow through the windings of the instrument.

It is evident that with the reversing switch in the position indicated, no current can flow through the left-hand coil winding; however, upon moving the blades of this switch to the right, contact is made at points 1 and 2 and immediately a flow of current is established which, passing through the left-hand coil, energizes it and thereby creates a magnetic flux in the iron core.

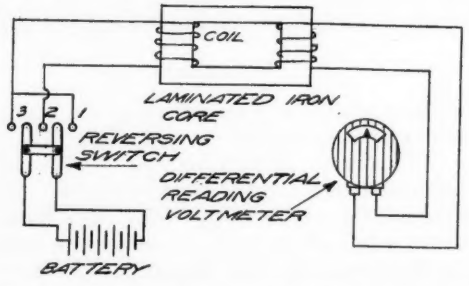


FIG. 87. ILLUSTRATING PRINCIPLE OF OPERATION OF THE STATIC TRANSFORMER

The establishment of this flux is not instantaneous, but comparatively gradual and as the right-hand coil lies within the influence of this increasing magnetic field, it has induced in it an electromotive force the direction and intensity of which is indicated by the connected voltmeter.

Throwing the reversing switch to the left so as to bring its blades in contact with terminals 2 and 3 causes the current to flow through the left-hand coil winding in the opposite direction. As a consequence, the magnetic flux established within the iron core is also of opposite direction as is also the direction of the electromotive force induced in the winding of the right-hand coil, a fact quite apparent from the reversed deflection of the voltmeter pointer.

It is evident therefore that by rapid manipulation of the reversing switch an almost continual although of fluctuating characteristic, electromotive force may be induced in the right-hand coil. If, however, instead of employing the direct battery current and the reversing switch, a source of alternating electromotive force such as produced by an alternating-current generator be used, the characteristics of the electromotive force induced in the right-hand coil will be similar to those of the source of supply although at any instant the induced

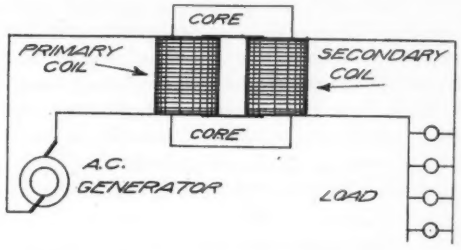


FIG. 88. A STATIC TRANSFORMER CONNECTED TO ITS SOURCE OF SAFETY AND LOAD

or secondary electromotive force is opposite in direction to the inducing or primary electromotive force. The transformer winding connected to the source of supply is generally termed the primary while the other, that connected to the load, is referred to as the secondary.

With the secondary circuit open and an electromotive force applied to the primary winding, the magnetization of the core alternates as does the primary electromotive, although the magnetizing action lags somewhat behind the current producing it. As a consequence, the changing magnetic flux induces within the core a counter electromotive force which opposes the applied electromotive force, thus limiting the current flow to an amount just sufficient to maintain magnetization of the core. This current is called the magnetizing current and may be represented by the letter M. With the secondary circuit closed, a like action takes place and a magnetizing action thus established which is exactly neutralized by the equal and opposite magnetizing action of the primary current I′. This results in an increased flow of primary current which is limited only by the resistance of the primary winding and the resistance (and current flow) of the secondary circuit.

The magnetizing action of the primary current I′ is measured by the product of this and the number of primary turns N′ or I′ N′. Similarly, the magnetizing action of secondary current I″ is measured by I″ N″ where N″ is the number of secondary turns. We then have I′ N′ equal to I″ N″ or, $(I' \div I'') = (N'' \div N')$ indicating the primary current to be to the secondary current as the number of secondary turns are to the number of primary turns.

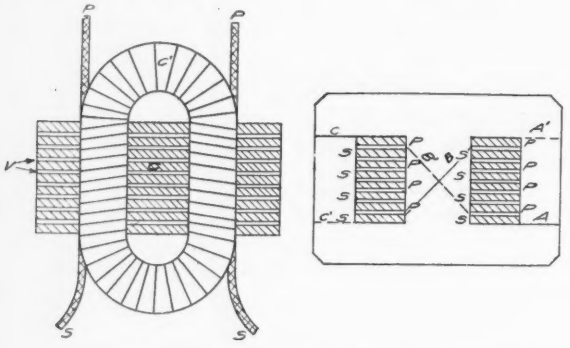


FIG. 89. CROSS SECTIONAL VIEW OF SHELL TYPE TRANSFORMER

Due to the rapid reversals of magnetization, a certain electromotive force a is induced in each turn of windings and as the total electromotive force induced in the primary is equal and opposite to the applied electromotive E′, we have E′ = a N′ and similarly in the case of the secondary winding E″ = a N″. The ratio of the primary electromotive force E′ to the secondary electromotive force E″ is then as the number of primary turns N′ is to the number of secondary turns N″.

Let us assume having a transformer with primary winding of 1000 turns designed for 2300 v. and with

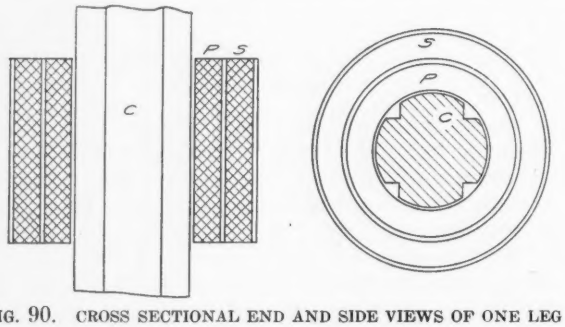


FIG. 90. CROSS SECTIONAL END AND SIDE VIEWS OF ONE LEG OF A CORE TYPE TRANSFORMER

secondary winding of 100 turns. What will be the secondary voltage?

We know $(E' \div E'') = (N' \div N'')$, or $(2300 \div E'') = (1000 \div 100)$, or $2300 \div E = 10$. Transposing, we have, $E = 2300 \div 10$, or 230, as the secondary voltage.

A transformer of the type just discussed generally termed the constant-potential transformer and used wherever a practically constant voltage (but variable current) is required is shown in elementary form in Fig. 88.

Transformer Details

Constant-voltage transformers may, according to structural details, be either of the shell or core types. Figure 89 illustrates a cross-sectional view of a shell type transformer. Coils C′ are surrounded on both sides by a built-up laminated iron core, C, provided with ventilating space V which also aid in the free circulation of cooling oil. The laminations are stamped in two parts and are built up about the assembled coils as shown, A, B and C being the divisions between the two parts of the top sheet and A′, B′ and C′ the divisions of the sheet next to the top; P and S are the primary and secondary coils respectively.

Such materials as fibre, paper, fuller board, oiled cloth and micanite are used as insulation. After the coils are wound, they are placed in a vacuum tank where an insulating compound is injected which thoroughly impregnates the windings.

Cross-sectional end and side views of one leg of a core-type transformer are shown in Fig. 90. P and S are primary and secondary windings respectively and C the laminated iron core made irregular in shape to facilitate the circulation of oil within the coil. The

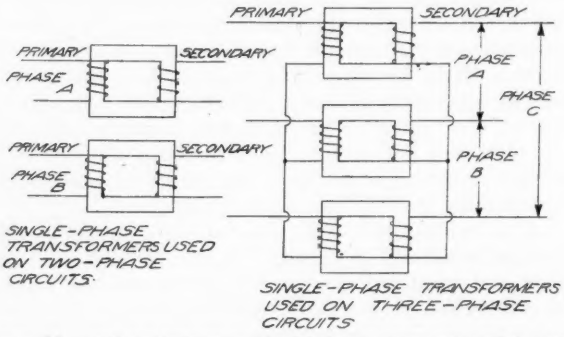


FIG. 91. SINGLE-PHASE TRANSFORMERS USED FOR TWO- AND THREE-PHASE WORK

manner of insulating and treating the coils is similar to that employed in the shell type of transformer.

Polyphase

For two- and three-phase work separate single-phase transformers connected as shown in Fig. 91 may be used. This scheme is, however, not always desirable and frequently therefore so-called two- and three-phase transformers are employed; in reality these are nothing more than single-phase units mounted on special cores such as illustrated in Figs. 92 and 93. In the case of the two-phase transformer the magnetic flux in core a is in quadrature to that in core c and that in return circuit b is equal to the geometric sum of Fa and Fc (as indicated at B Fig. 92) or Fb. Its direction relative to Fa and Fc is as shown. Similarly the direction and value of the magnetic flux in each of the legs of the cores of the three-phase transformer is as shown in the diagram (B) Fig. 93. The magnetic flux in each of the legs is displaced by 120 deg.

Electrical Connections

Where three transformers are used on a three-phase three-wire system, the primaries may be connected to the supply mains either in delta or Y and the secondaries may likewise be connected either in delta or Y, thus allowing the employment of any one of four

schemes, namely: Primary delta and secondary delta; primary Y and secondary Y; primary delta and secondary Y; or, primary Y and secondary delta. The primary delta—secondary delta scheme is, however, the one usually employed, for with it any one of the single transformers may be cut out without rendering the system inoperative. Under such conditions, however, the capacity of the bank would be reduced to 0.577 of that of the three units when working together.

Auto-Transformers

The term "auto-transformer" refers more properly to the scheme of connections employed than to any particular type or form of piece of apparatus.

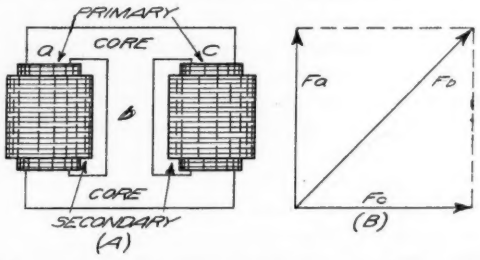


FIG. 92. TWO-PHASE TRANSFORMER AND VECTOR DIAGRAM OF MAGNETIC FLUXES

In Fig. 94 at A is shown an elementary diagram of connections of a single-phase transformer designed to step down from 1000 to 100 v. Frequently it is desirable or necessary to raise the voltage of a distribution system at some given point and in order to avoid the necessity of installing otherwise expensive voltage boosting apparatus such a transformer may be used instead. Its application is shown at B, Fig. 94, and from this it is evident that with the primary of the transformer connected across the line and its secondary in series with the line (beyond primary connections) the line voltage

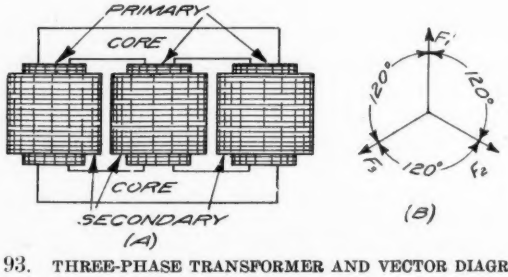


FIG. 93. THREE-PHASE TRANSFORMER AND VECTOR DIAGRAM OF MAGNETIC FLUXES

due to the added 100 v. will be 1100 v. This may more properly be called a boosting transformer although by reversing the secondary connections it is possible to cause the secondary 100 v. to oppose the primary 1000 v., in which event, of course, the transformer would rather be called a "bucking" transformer. If so employed, the primary voltage would be reduced to 900 v.

The advantage of using such a scheme lies in the fact that a comparatively small transformer may serve the same purpose as would otherwise require a much larger unit. With a current of 500 amp. delivered to the receiving circuit at a voltage of 1100 v., the total power would be equal to 550 kv.a., the required capacity of a transformer if used in a regular way. By the use of an auto-transformer, however, and where the secondary voltage is 100, the capacity required is equal to but 500 times 100, or 50 kv.a.

Questions and Problems for Review

Explain the principle underlying the operation of the static transformer.

(2) How do primary and secondary voltages and currents compare with the number of turns in the primary and secondary windings?

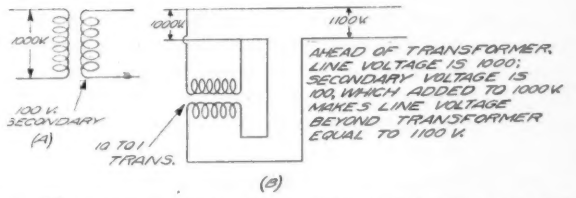

1000V.
100 V. SECONDARY
(A)
10 TO 1 TRANS.
1000V.
1100V.
AHEAD OF TRANSFORMER. LINE VOLTAGE IS 1000; SECONDARY VOLTAGE IS 100, WHICH ADDED TO 1000 V. MAKES LINE VOLTAGE BEYOND TRANSFORMER EQUAL TO 1100 V.
(B)

FIG. 94. ILLUSTRATING THE AUTOTRANSFORMER AND ITS APPLICATION

(3) When necessary to boost the voltage of a 2200 v. circuit to 2400 v. and the receiving device at the end of the line requires 250 amp., what size of step-up autotransformer would you use?

When high potential differences exist between conductors, the insulating property of the surrounding gas partially breaks down, and a conduction of electricity through the gas takes place, usually accompanied by a glow at either one of the conductors or in the intervening space. This glow is called the corona. The phenomenon is commonly seen when static machines or Tesla coils are operated in the dark, and less frequently from the tips of lightning rods during an electric storm. The corona is evident at night, as it surrounds very high voltage alternating current transmission lines. The conduction represents a loss of power, which on long lines may become an important item. In 1912, F. W. Peek, by a stroboscopic method, showed that there is a difference between the corona discharge from positive and negative conductors. This difference indicates that corona caused by alternating potentials is a combination of two effects; and in order to study these effects separately and thus to learn the true facts concerning the phenomenon, continuous potentials must be used. A study of the corona caused by continuous potentials may produce engineering data of value owing to the increasing development of high tension direct-current generation and transmission. Previous to 1914, Watson and Schaffers were the only men who had experimented on the direct-current corona.

Because of the desirability of a greater knowledge of the direct-current corona, the Physics and Electrical Engineering Departments of the University of Illinois determined to carry out detailed research to develop a satisfactory theory for the corona phenomena. The results of the experimental research which has been completed during the last few years, have been published by Earle H. Warner with Jakob Kunz, as Bulletin No. 114 of the Engineering Experiment Station of the University of Illinois, Urbana, Ill., Copies of this bulletin may be obtained without charge.

Turbo-Generator Failures and Suggested Improvements

MECHANICAL AND ELECTRICAL WEAKNESSES OF FORMER AND PRESENT DESIGNS; SUGGESTIONS FOR COOLING WITH WATER.

ONE of the principal factors which keep power plant machinery from reaching its theoretical efficiency is safety, which is akin to reliability. Equipment which proves unsafe will not have continued use regardless of its efficiency. The accomplishments in the development of electrical machinery particularly have been due in numerous cases to discovery of materials and arrangements which make higher potentials possible, greater current densities practicable and higher temperatures less destructive. All of these features have long been recognized as of advantage in various cases of efficiency and economy, but with these higher values have come hazards which have and do yet prohibit the practice of using the value which theoretically would give the highest efficiency.

This fact is well brought out in a paper presented before the Institute of Electrical Engineers in England by J. Shepherd on the Failures of Turbo-Generators and Suggestions for Improvements, which was published in a recent issue of Engineering from which the following abstract was prepared.

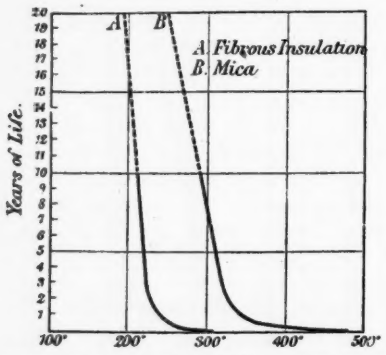


FIG. 1. CURVE OF TEMPERATURE AND LIFE OF INSULATION

After several years of experience in many stations and with different designs of machines, the more usual types of failures have been determined and may be roughly classified under: (1) Mechanical weakness, (2) Electrical weakness, (3) Heating and fire risk, (4) Ventilation difficulties. The various defects are generally very closely correlated, as will be discussed later in the paper.

MECHANICAL WEAKNESSES

THE EFFICIENCY of the steam turbine increases materially with its speed, and modern generators are now run at speeds which would not have been considered practical 6 yr. ago. The centrifugal stresses in the rotor teeth, upon the rotor coils and their insulation are serious in amount, particularly so with speeds of 3000 r.p.m., the centrifugal forces increasing with the square of the speed.

To limit these stresses and retain the maximum speed of rotation, the diameter of the rotor is reduced to the smallest practical dimension, the increase in size for increasing output being more in length than in diameter. As a result, the running speed of the generator is generally above its first "critical" speed, except in the case of the double generators of the Ljungstrom combination, and therefore each time the plant is started and stopped, the rotor must pass through the first critical speed with its attendant risks.

One serious result of the high speeds of rotation is the difficulty of effectively holding the rotor coils against centrifugal forces. The portion of the coils within the winding slots is retained in place by metal wedge driven into dovetailed recesses, machined out of the top of the rotor teeth. The portion of the windings forming loops at each end of the rotor cannot be held in this manner. Originally they were secured in place by steel wire bands wound tightly upon the completed coils. Solid rings of high tensile steel are now used instead. These rings are turned out of substantial forgings in which internally-hidden flaws may exist, and, from the standpoint of reliable mechanical strength alone, they have not the advantage of drawn wire bands.

The choice of insulation capable of withstanding the pressures is very limited, especially as prolonged heating of the insulation and the difference between the expansion of the copper and of the wedge are also involved.

The portion of the rotor winding within the rotor slots must of necessity preserve its shape under the centrifugal forces, but the unsupported portions of the coils at the end loops have no lateral support, and there is always a risk of distortion or side slip at high speeds.

The internal losses of a modern generator are about 4 per cent to 5 per cent of the rated output, and the heat resulting from these losses is almost invariably dissipated by forced air ventilation through specially-constructed air vents in the rotor and stator. In the rotor these vents are provided under the slot windings and, to find room for them, the rotor must be increased in diameter, with increasing difficulties from centrifugal forces. With higher speeds, smaller diameters, and increased length of rotors, it becomes a matter of great difficulty to pass the required amount of cooling air through the rotors. Generally there is adequate room in the stator for the air ventilating spaces at the expense of iron space. On modern machines, the volume of the stator taken up by ventilating spaces is from 15 to 25 per cent of the total volume. The stator is divided longitudinally by air ducts spaced about 2 in. apart, the passages being maintained by spacing fingers attached to the steel stampings. In addition, longitudinal air passages are provided in the cast-iron framework behind the discs and sometimes through the stampings in addition.

This method of open construction gives a mechanically weak form of stator core and, under the alternating stress, chattering of the teeth may occur with consequent breakage. The result of the vibration on the insulation of the stator bars is obviously undesirable, without the further trouble of broken teeth. A further mechanical weakness occurs at the end of the stator where the winding must have spacings for the air freely to pass between them. The windings, although mechan-

ically and almost continuously held in the winding slots can only be clamped at intervals along the end connectors.

Electrical Weaknesses

The electrical weaknesses in turbo-alternators have generally developed since the size of the machines and the systems to which they were connected increased to over 30,000 kw. on a single set of bus-bars. The insulation on the stator bars is almost invariably micanite, worked on hot with a Haefley wrapping, and a thickness of 0.15 in. of insulation is usually sufficient for ordinary working pressures. Micanite insulation is admirable so long as it is not overstressed during short circuits. If, however, the stator bars are not adequately supported, bending will occur and cracking of the micanite insulation will result usually just inside the ends of the stator cores. As a rule, such a crack cannot be detected, and its very existence is unknown until a breakdown occurs, perhaps weeks or months afterwards.

From the constructional point of view the one bar per slot of stator winding has advantages. The bars are of reasonable size, and the number of joints is less. There is the important advantage of thinner insulation and smaller temperature gradient across the insulation.

Owing to the considerable depth of the stator slots, considerable magnetic leakage takes place across them, and division of the stator bars is necessary to reduce eddy currents in them, especially if the bars are of substantial size.

The greatest electrical weakness in turbo-generators constructed a few years ago was their inability to withstand the stresses set up on short-circuit. If even moderate movement of the stator bars occurs, cracking of the insulation is probable, especially if the insulation is of some age, setting up a defect which will develop sooner or later into serious trouble. If a solid conductor could be used, a very rigid bar construction is possible, and the risk of conductor bending under short circuit would be small.

In the latest method of construction, the stator bars divided radially into several copper tapes, each separately insulated, and each tape is connected to another tape in the several bars forming the winding pitch at the ends of the stator. At each joint the tapes are twisted relatively to each other, giving a complete change of position in each complete phase winding from the star point to the main terminal.

This construction eliminates eddy currents and gives a uniform distribution of current in every section of the stator bar. It has the additional advantage of small joints, which enable the tapes to be fusion welded together. The only large joints occur at the star points and at the main terminal connection, and these can be arranged well out of the revolving field. However, a bar laminated so completely has little stiffness or mechanical strength and requires very careful support.

The popular remedy against short-circuit stresses is the provision of high reactance within or without the machines, reducing the current on short circuit to from 8 to 10 times full-load current. This reactance can be built into the machine itself by providing the necessary magnetic leakage, and internal reactance gives the greatest protection to a machine. External reactance gives protection from feeder or bus bar troubles, but not from internal short circuits. But whether the inductance be internal or external, the result on the regulation of the machine is the same, resulting in poor regulation. To overcome this, each generator must be controlled by an automatic regulator giving satisfactory pressure on ordinary loads.

In addition to the short-circuit stresses, there is mutual attraction between the adjacent end turns of the same phase, and repulsion between the adjacent end

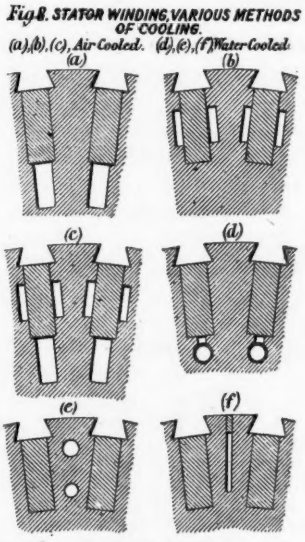


FIG. 2. VARIOUS METHODS OF COOLING STATOR WINDINGS

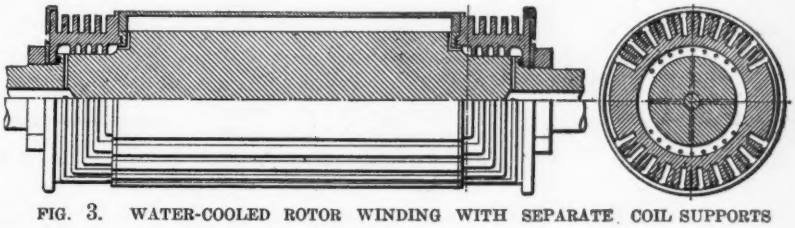


FIG. 3. WATER-COOLED ROTOR WINDING WITH SEPARATE COIL SUPPORTS

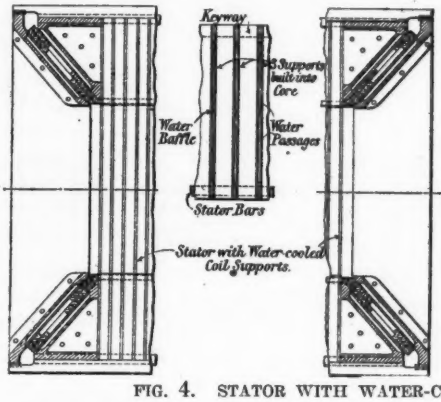


FIG. 4. STATOR WITH WATER-COOLED COIL SUPPORTS

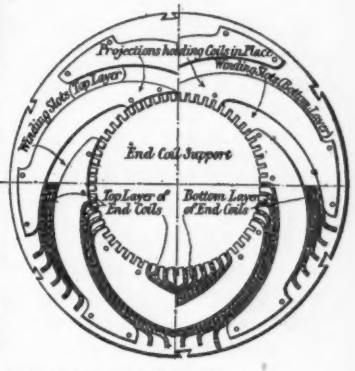

Projections holding Coils in Place
Winding Slots (Top Layer)
Winding Slots (Bottom Layer)
End Coil Support
Top Layer of End Coils
Bottom Layer of End Coils

FIG. 5. DETAILS OF WATER-COOLED END COIL SUPPORTS

turns of different phases. The attractions and repulsions increase as the square of the alternating current, causing vibrating forces corresponding to twice the periodicity of the system.

In large generators the ordinary method of leading away the current of the stator is open to improvement. The winding is usually terminated in split connections, clamped together by small screws with slotted heads, a somewhat crude finish for a plant of considerable size. In all large systems it is more satisfactory to lead away each phase by a separate lead-covered cable, taking care that substantial joints are made between the cable and the stator windings, and that such joints are well clamped mechanically against all possible movement.

Heating and Fire Risk

With the old type of low-speed generator the fire risk was not considerable, as the proportion of inflammable material was small. With a modern turbo-alternator the conditions are quite different; and owing to the high speed and compact design with small volume of active material, a very considerable portion of inflammable insulation is built into the machine. As a consequence of forced air ventilation, the generator is totally enclosed and, when working, no part of the winding is open to inspection. A fire within the machine can originate in a variety of ways, such as defective joints, a short circuit to earth or between the stator windings, failure of insulation or the like. An arc, however started, has immediately a considerable amount of energy fed into it, until the field current is cut off and the machine isolated from the bus-bars by relay protection.

The inflammable character of the winding may be augmented by oily vapor and dirt carried into the machine by the ventilating air and deposited as sticky material on the conductors.

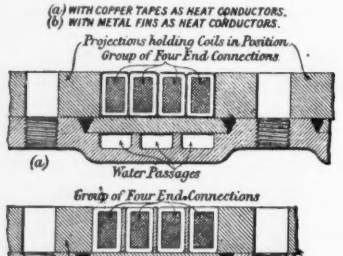

(a) WITH COPPER TAPES AS HEAT CONDUCTORS.
(b) WITH METAL FINS AS HEAT CONDUCTORS.
Projections holding Coils in Position
Group of Four End Connections
(a)
Water Passages
Group of Four End Connections
(b)
Water Passages
Projections holding Coils in Position

FIG. 6. DETAILS OF WATER-COOLED WINDING SLOT ON END STATOR SUPPORT

Ventilation Troubles

The amount of air required to carry away the internal heat is dependent upon the internal losses and upon the permissible temperature rise. Allowing a rise of 50 deg. F., in the cooling air, and a loss of 4 per cent in the generator, about 4 cu. ft. of air per minute per kilowatt of output is sufficient, and this allows for a certain amount of the air being short-circuited within the machine. Even under the cleanest conditions, the air has sufficient dust suspended to choke up the internal ventilating spaces in time, and filtration of the air becomes necessary in some form or other. Further, even in our temperate climate it is desirable on the hottest days of summer to cool the incoming air.

Air washers of the spray type have been used to a considerable extent, but in several cases they have not justified the high opinion in which they were formerly held, and more or less free moisture has been introduced into the machines by their use. Except in very exceptional conditions some form of filtering and cooling air is necessary. The amount of dust caught by a dry filter from an air blast of 40,000 cu. ft. of air per minute has been found per week of continuous working to be 5 lb. in the center of London and 2 lb. at the outskirts of London.

Unless this dust be removed, it is sufficient to choke up the narrow air passages in the rotor and stator, which passages can be cleaned only with considerable difficulty, even when the rotor is removed.

Suggested Lines of Improvement

From the operating point of view, the requirements of modern turbo-generators are (1) reliability, (2) efficiency, (3) ease of operation. Reliability calls for machines which shall be fireproof, the coils of which cannot break down or overheat, the insulation of which shall not fray, crack or deteriorate, and the electrical joints of the machine shall be so constructed that there is no chance of their giving way under load. Most operating engineers would consider reliability the most important of the above conditions, and would be willing to obtain it at the sacrifice of some electrical efficiency.

Ease of operation requires some better means of knowing what is happening inside the enclosed frame of the machine. It ought to be possible to determine continuously, with some accuracy and by simple means, what is the temperature of any part of the machine, and it is desirable to anticipate breakdowns by the indication of rising temperature of the faulty part, or otherwise, before the fault develops.

The output of the machine should be independent of air temperatures and if possible there should be some reserve of capacity to meet sudden overloads. With a view to considering how these conditions may be met,

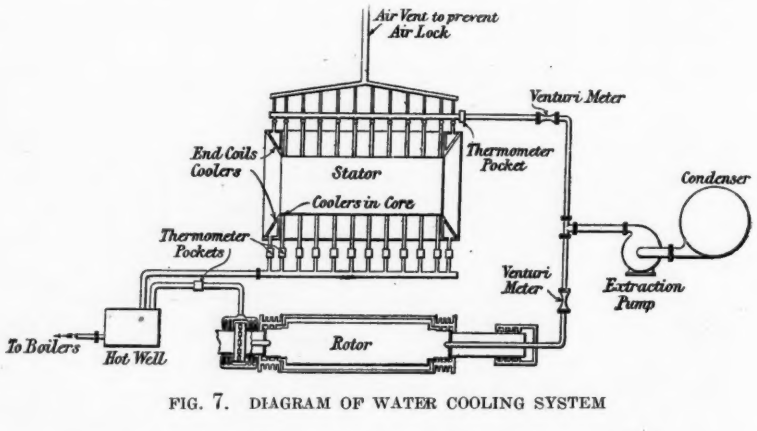


FIG. 7. DIAGRAM OF WATER COOLING SYSTEM

the several causes of failures already mentioned will be considered, and the remedy for each type of failure will be briefly discussed.

Rotor Coils' Centrifugal Force

The difficulties of centrifugal stress resulting in the crushing of insulation between the turns of the rotor windings and the distortion of deep narrow coils, have already been indicated, and the difficulty of securing the end loops has also been mentioned. The first remedy is to manufacture a suitable insulation, and is beyond the scope of this paper. When it is realized that a pressure of over 2 tons per sq. in. may be encountered with the insulation between and around the outer turns, and that the insulation must stand continuously a temperature of 200 deg. F. it will be seen that the problem is not one of easy solution. The choice of suitable insulation at present is restricted to mica and various forms of hard paper. The coil should be made of as great a width as possible, and the separate turns laid flat upon each other. The support of the coils against distortion at the end of the loops can be prevented by substantial metal packing between the loops.

The safest band over the coils would be one of drawn steel tape, which would require centering by other means than the coils themselves. This form of banding is the one used for the much more severe conditions required by the reinforcement of high-velocity gun tubes.

A flexible wire or tape band has other advantages over a solid ring; the distribution of centrifugal stress is not uniform either axially or circumferentially, and this unequal loading sets up secondary stresses, in solid bands. With a laminated tape band, each turn can adjust itself to the strains upon it. The reduction in rotor diameter is a method of reducing the centrifugal stresses.

Rotor Couplings

The difficulties of flexible couplings of the claw pattern, with excessive pressure upon the line of contact, together with defects in centering and of running balance, have caused a gradual adoption of solid flange couplings.

Even with the most thorough lamination of conductors, no trouble usually occurs through lack of stiffness in the portion of the coil within the winding slot, except at the very extremities of the slot where displacement of the end connections may give rise to trouble. It is difficult to obtain a firm wrapping from a thoroughly laminated bar and the remedy would appear to be less drastic division of conductors, or a better nesting together and impregnation before wrapping.

The end connections, if attached to weak laminated stator bars, are difficult to stay adequately. Usually fiber spaced blocks are laced between the ends of the stator bars at the junction with the end connectors; these give mutual support between the bars in a circumferential direction, but stresses on the short circuit are also radial from the center, and in this direction the space blocks give but little support.

The remedy is to provide continuous coil supports having winding slots for the entire length of the end connectors.

Joints

Soldered joints have of course the advantage of allowing disconnection for repairs at any time, but in the ideal machine under consideration no repairs would be necessary, and no joints would require disconnection until the generator went out of service with old age. Under these conditions all the joints would be fusion welded, except possibly in the case of the largest joints, where clamped and soldered connections would be permissible if well removed from the rotating field.

Heating and Fire Risks

Owing to the limitations of air cooling, it has been argued that, provided suitable insulation can be found which will safely stand temperatures of 250 to 300 deg. F., it is neither necessary nor desirable to limit the temperatures to lower figures. So far as is known, the only two insulating materials which can withstand such temperatures for any prolonged period without charring are mica and asbestos. As a rule, mica cannot be employed without a fibrous or paper backing on to which it is built by varnish or gums, whilst asbestos requires similar material to fill up the pores and render it suitable for insulation use. Such varnish or gums soften at temperatures approaching 300 deg. F. The melting-point of solder if used is also an important matter; for ordinary mixtures it is about 370 to 390 deg. F.

Even assuming insulation difficulties are overcome, there remains the question of thermal expansion at these high temperatures.

This increase, though very small, takes place while the coils are subjected to severe lateral pressure, and the effect of movement under such conditions will certainly shorten the life of the insulation.

The following figures on the resistance to crushing of mica are given by Professor Miles Walker:

"Mica (pure white) 0.010 in. thick, when tested for crushing between copper plates, breaks down at 40,000 lb. per sq. in., owing to the flow of copper. When tested between steel plates, it will withstand 90,000 lb. per sq. in."

From these figures, it would appear that the slight movement of the copper plates is sufficient to flake and destroy the mica at a very reduced mechanical pressure. The effect of the probably greater and continued movement under thermal expansion cannot be otherwise than detrimental to the mechanical strength and life of the insulation.

The relation of the temperature to the useful life of the insulation is of great importance. Insulation secured in place and not subjected to mechanical stresses, such as that upon the separate turns of stationary field magnets, may be satisfactory, even when quite charred and devoid of any mechanical cohesion. With turbo-generators, the useful life of insulation practically ceases when it has mechanically failed.

The matter is briefly dealt with by Messrs. Steinmetz and Lamme.* Two curves are given, showing the relation of the useful life of insulation to the temperature, for:

(A) Fibrous insulation, including fabric and paper;

* Transactions of the American Institute of Electrical Engineers, vol. xxxii, page 79.

(B) mica and micanite insulation. The results have been reduced to Fahrenheit scale, and each curve has been continued to a hypothetical life of 20 yr. (see Fig. 1).

It would appear that for large machines working continuously night and day for months together, a temperature of 150 deg. F. has much to recommend it from the point of view of capacity to meet sudden overloads and long life of insulation.

Having the fire risk in view, all inflammable packing insertion and all fibrous insulation should be avoided in both stator and rotor. The ideal insulation is yet to be found, but it would have a substantial body of mica built up without inflammable gum or varnish and with some degree of flexibility.

Ideal Machine

Consideration of the usual defects already mentioned shows that air ventilation gives rise to the following difficulties.

1. Impossibility of equal distribution of air with presence of hot spots.

2. Weak construction of stator, open type of end windings and serious fire risks.

3. Larger diameter of rotor with greater centrifugal forces; inadequate cooling of end winding loops.

4. Higher temperatures than desirable, with reduced life of insulation.

The ideal machine must be free from these defects, and should also embrace the following features:

(a) Coils to be continuously held against movement under mechanical forces, but free to expand with heat.

(b) Working temperature and output independent of air conditions.

(c) Capable of working at a much reduced temperature and to be practically fireproof.

To obtain these advantages, all windings, including rotor end loops and stator end connections, would be contained in continuous metal winding slots, with adequate freedom for expansion. The windings would be securely supported over their entire length, and the heat generated in the copper would be directly conveyed to the surrounding supporting metal, and dissipated by liquid cooling.

Arrangement	Proposed by	Size of Ducts taken on illustration	Relative Cooling Capacity
Fig. 2 (*a*)	Ordinary arrangement	2½ in. by 1 in., one air duct	1
Fig. 2 (*b*)	Siemens	2 in. by ½ in., two air ducts	0.8
Fig. 2 (*c*)	Schuckert	2½ in. by 1 in., one air duct 2 in. by ½ in., two air ducts	1.8
Fig. 2 (*d*)	Parsons	1-in. water tube	54
Fig. 2 (*e*)	Siemens Dynamo Works	1-in. and ⅝-in. water holes	83
Fig. 3 (*f*)	Author	3½-in. by ⅝-in. water slot	89

Various designs have been proposed using liquid cooling. The initial adaption of water cooling to modern machines is to be credited to Messrs. C. A. Parsons & Co., Limited.

By splitting up the water paths in the machine, and by providing adjusting cocks in the water supply to each cooling device, it becomes a simple matter to determine the temperature of each part of the machine and to adjust the water flow to give a uniform temperature with elimination of hot spots, and having regard to the superior cooling effect of water over air, a lower temperature would be possible with enhanced life of the insulation.

A further and great advantage would be in the provision of continuous supports to the end connection of both stator and rotor windings, which at present are the weakest features of most generators.

As a more detailed comparison of the two methods of cooling, various designs of cooling rotor windings have been drawn out for a modern high-speed rotor (Fig. 2).

Taking the ordinary air velocities in rotor ducts as 10,000 ft. per min., and a moderate water velocity of 500 ft. per min. (8.3 ft. per second), the relative cooling capacities of the streams of air and water are as shown in the table.

A rotor constructed with cooling ducts as shown in Fig. 2 (f) is detailed in Fig. 3, where water-cooled supports are shown for the end loops against sideslip.

Water cooling for the stator does not appear to have been developed to any great extent; hollow water-cooled stator frames have been designed by Herr E. Huther, and I am informed that a few machines were constructed by the A.E.G. on these or similar lines, but not of recent years.

Geisenhorner, of Schenectady, proposed cooling devices of thin stamped metal for building into the stator core, but I have found no record of machines using these devices having been constructed.

Combination of Water Cooling and Coil Supports

If full advantage is to be taken of water cooling, it would appear desirable for the cooling arrangements to be in close proximity to the coils, with very low resistance heat paths, and to serve the double purpose of coolers and coil supports. Designs have been developed by the author upon these lines, and are indicated in diagram forms in Figs. 2 (f), 3, 4, 5, 6 (a) and (b), and 7.

Careless Elevator Operation

Regardless of all that has been published relative to "safety first," acts of carelessness go merrily on.

One of the most careless acts I see daily, is elevator operators starting their car with one hand on the starting rheostat, the other hand held against the gate, shoving it closed while the car is moving. In a descent, the position the arm takes upon the gate is about 60 deg. ere they let loose of the gate.

Suppose a cuff button, or the clothing should get caught on the grill work, what would result?

The operator would be jerked away from the rheostat toward the moving car frame, and no doubt crushed before anybody could stop the elevator.

If such an accident should happen with a load of hysterical people aboard, there is no way to prophesy what might occur. There is absolutely no excuse for such work, and the superintendent of the building should stop it at once—for all time. It is thoughtlessness on the part of many operators, due to the manner in which they were trained, and this is a sore spot in the heart of those who are trying to establish safe working conditions.

J. B. Dillon.

Belts and Belt Guards

Prepared by the Engineering Department of the National Safety Council

BELTS must be reckoned among the industrial appliances which have occasioned a great number of serious accidents. Attention cannot be too forcibly called to precautions which should be taken in the management and safeguarding of these dangerous appliances.

Leather belts are in general use, except in situations where there is an excess of moisture, heat, grit, or other exceptional conditions.

Engineering manuals indicate a strength of 2000 to 5000 lb. per square inch for solid leather belts. This may be reduced at lacing or joint, even if well put together, to about 1000 to 1500 lb.

The ordinary type of belting cannot safely stand a temperature higher than 130 deg. F.

The safe working load may be learned from manufacturers of belts, and this load should never be exceeded.

Belts should be adjusted to tension under conditions as closely approaching normal as may be devised. In damp or rainy weather, belts are liable to stretch. This fact should be considered in computing tensions in new adjustments.

Countershafts with adjustable hangers are advisable for new installations.

Average distance between shaft pulleys for small belts should not exceed 15 ft.; for larger belts, not to exceed 25 ft., and for main belts on large pulleys, not to exceed 30 ft.

Splicing and Lacing

A GENERAL RULE in many large plants reads about as follows: "Endless belts should be used wherever possible; in case endless belts cannot be used (and the circumstances permit), then the belts should be laced with rawhide or leather lacing. Belt hooks or metal lacing should not be used except where absolutely necessary in emergencies."

The objection to the use of metal in joining belts is its probability of presenting sharp projections which will injure hands or catch clothing. For this reason, if such lacing is used at all, special care should be taken to see that it is not used in a situation where the hands or clothing is likely to come into contact with the belt.

Authorities agree that splicing and cementing is safer than any other method of joining belts. Claim is also made that belts joined in this manner will wear longer, cut labor cost, do smoother work and give better service.

Ends of belts should be carefully scarfed down, covered with cement, and firmly pressed together. It is essential that the work be carefully done by experienced workmen. The scarfing should be so arranged that the pulley where slipping is more likely to occur will tend to smooth down the scarf end against which it rubs in the event of a slip, instead of tending to roll this end up.

Vulcanizing, with stepping splice, is recommended for rubber belts.

When belts are laced, rawhide or leather lacing is recommended. Ends should be cut short down to the belt and care should be exercised to avoid broken turns.

Belts usually weaken and break near the lacing. To avoid weakening the belt too much, holes for lacing should be made with oval punch, with the longer diameter parallel to sides of belt. If the width of the belt will permit, edges of holes should not be nearer than ½ in. from sides nor less than 1 in. from ends. The second row of holes should be staggered and about same distances from first row as first row is from end of belt to be spliced.

Square the ends of the belt, if cut. Start lacing from the center, lacing both sides with equal tightness. Do not cross lacings on side running next to face of pulley. Keep ends of belt exactly in line while splicing.

If practicable, lacing should not be done while the machinery is in motion, and the beltman should be protected against accidental starting of the machinery, preferably by locking the controlling device. When the line shaft cannot be stopped, special precautions should be taken to prevent the belt coming into contact with the pulley or wrapping on the shaft by the use of a belt perch or other attachment.

Use of rawhide or leather lacing is advocated in preference to metal lacing. The danger from wire lacing arises from two principal sources: The working out of the clinched ends of the wire and the ragged ends produced by a fracture. If the wire lacing must be used, it should be in some form of spiral continuous wire stitch, so that there will be only two clinching points to turn into the leather on each end of the belt, the two lacings being hinged together. Wire lacings, unless machine made, require a high degree of skill. Care should be taken that the wires lie below or flush with belt surfaces and not touch on pulley.

Heavy toothed clinches of the so-called "alligator" type are less dangerous than the wire lace or wire staple type, partly because of their weight and strength and partly because the clinched ends run on the pulley side. The best types have a double grip.

Rivets offer the possibility of ragged ends on the opened rivet.

Certain forms of link fasteners avoid the need of clinching, but they are somewhat difficult to aline and present open joints that may easily catch a garment.

Belt Guards

ANY PORTION of an overhead belt 7 ft. or less from the floor, or which must be approached while in motion, should be guarded on the sides and bottom. Heavy or fast-running belts more than 7 ft. above the floor, so located that should they break, they would endanger persons below, should be guarded underneath.

It is obvious that the guards should be capable of withstanding not only the weight of the belt, but blows or stresses due to the possible entanglement of the belt. Such guards are usually of the hanging type and should be smooth on the inner surfaces, of a greater width than the belt, and should be brought up around the pulley upon which the belt travels downward, to avoid the broken end whipping around the guard.

All vertical and inclined belts should be so guarded

that a hand or other part of the body cannot project through, over, around or under the guard and be caught by a moving part. Authorities are practically unanimous that if the projection be placed 15 in. or more from any moving part, a height of 3 ft. 6 in. is sufficient for the guard. When the guard is placed less than 15 in., but not less than 6 in. from the thing guarded, the heights recommended vary from 5 to 7 ft., with the majority in favor of a guard 6 feet high, with openings in the filler not greater than 1½ in. If the clearance is less than 6 in., then the guard should be 6 ft. high, with no opening in the filler larger than ½ in.

A guard should not be placed so far from the thing guarded as to invite the workman to get between the guard and the moving parts, or so far as to make it inconvenient to reach bearings, etc., while standing outside the guard. It is recommended that the maximum distance at which a guard be placed from the thing guarded should be 20 in. The Council advocates the following safe practices as to heights of guards and sizes of openings in the same:

Distance from Thing Guarded	Height of Guard	Size of Openings
15 to 20 in.	3 ft. 6 in.	1½ in.
6 to 15 in.	6 ft. 0 in.	1½ in.
0 to 6 in.	6 ft. 0 in.	½ in.

When the upper part of a horizontal belt is less than 6 ft. from the floor level, the belt may well be guarded over the top, instead of carrying the guard up 6 ft., or a 3 ft. 6 in. railing should be placed at least 15 in. and not more than 20 in. horizontally from the edge of the belt.

When belts pass through a floor (or where any guard is placed around a floor opening), a 6-in. solid section or toe-board should be placed at the bottom of the guard to prevent objects rolling or being kicked through the floor opening. Where belts pass through openings in a floor or wall, provision should be made to guard against friction due to the belt rubbing on the edge of the opening. The placing of rollers at the two edges of the belt, so that if the belt rides to one side it will strike the roller and cause less wear and friction, is considered better practice than facing the opening with sheet metal, as is sometimes done.

Metal is preferable to wood in the construction of guards. Wooden guards, especially if oil soaked, increase the fire hazard and are more expensive in upkeep. Metal guards are practically indestructible, wear better and are more substantial. Where guards are subject to acid fumes, wooden guards may be necessary, however.

All guards should be of rigid and substantial construction. The railing guards, placed from 15 to 20 in. from the moving parts, should be of the double type, with the top rail 3 ft. 6 in. from the floor and an intermediate rail midway between the top rail and the floor.

Hot Process Water Softening

To What Extent Heat Aids Reaction and Sedimentation. By George H. Gibson*

THE HOT-PROCESS softener in its present form is a recent development. By taking advantage of the fact that chemical reactions are more rapid and complete in hot water than in cold water, more efficient removal of scale and sludge forming substances is obtained. The apparatus performs the functions of the open feed-water heater usually found in steam boiler plants, in addition to those of a softener, and less space, lighter foundations, less housing, less piping and fewer fittings are required than for a cold-process softener, plus an independent heater. There are several reasons why scale-forming matter is more completely removed from hot water than from cold water.

Effect of Heat Upon Reactions

Chemical reactions are enormously accelerated by heat. This is a well-known and generally recognized fact and was used in the household for ages before it assumed the dignity of a law of chemistry. Everybody knows that dishes and clothes are washed more rapidly and thoroughly in hot water than in cold water; paper pulp is causticized in hot water. The exact law connecting temperature and rapidity of chemical reaction has never been determined accurately, some chemists stating that the speed of reaction doubles for each 10 deg. C. added to the temperature, and others that chemical reactions are speeded up approximately as the twentieth power of the absolute temperature. These formulas are not in agreement, but everybody concedes that there is a tremendous increase in speed of reaction with rise in temperature.

Some years ago, experiments were made in our chemical laboratory to determine the effect of temperature upon the reactions which take place between softening reagents and scale-forming matter in boiler feed-water. The results are shown graphically in Fig. 1.

It will be seen that the reduction in hardness; that is, in content of calcium and magnesium salts, is much greater at the end of 10 min. in water at 210 deg. F. than at the end of 5 hr. in water at 50 deg. F. in fact, 24-hr. treatment in cold water does not bring the scale-forming matter down as much as does 10 min. treatment in hot water. Subsequent heating to the boiling point of the sample which has stood at 50 deg. F. for 5 hr. reduces the magnesium hydrate to less than 1 grain per gallon, but the same result is obtained in hot water in 10 min. In performing these experiments, only sufficient softening chemical was added to combine with the scale-forming substances. In practice a slight excess is used, which reduces the hardness to lower figures.

The effects of heat can be verified in a rough way by performing a simple experiment. Place one pint of cold, untreated boiler feed-water in each of two beakers; bring one of them up to the boiling point, but leave the other cold. Then add to each the amount of reagent theoretically required for transforming the scale-forming substances.

* Of the Harrison Safety Boiler Works.

Stir thoroughly the contents of each beaker and note results. The reaction and sedimentation in the hot water will be much more prompt than in the cold water.

After precipitation has ceased in the cold water, decant the clear liquid and heat it to the boiling point. A marked after-precipitation will result, showing that the reaction in cold water was not complete. Do the same with the clear water from the hot water beaker. No after-precipitation will occur, so it is conclusively shown that the reaction is not only more rapid in the hot water, but is also more complete.

The substances resulting from the transformation of scale-forming matter are more nearly insoluble in alkaline hot water than in cold water hence less are carried into the boilers in solution by water which has been softened hot.

Effect of Heat Upon Sedimentation

The precipitates resulting from the transformation of scale-forming substances also settle more rapidly and completely from hot water than from cold water. Solid particles suspended in water settle to the bottom if their density is greater than that of the water or rise to the top if their density is less than that of the water. The force acting upon the particles is its weight less the weight of water displaced and the force by which it is resisted depends upon the extent of its surface and the viscosity of the fluid in which the particle is suspended, multiplied by the velocity of fall. A maximum velocity is reached at which the retarding force is just equal to the accelerating force.

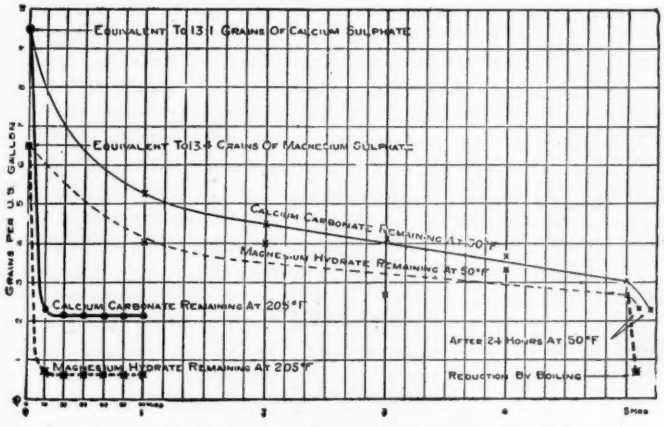

Equivalent To 13.1 Grains Of Calcium Sulphate
Equivalent To 13.4 Grains Of Magnesium Sulphate
Grains Per U.S. Gallon
Calcium Carbonate Remaining At 50°F
Magnesium Hydrate Remaining At 50°F
Calcium Carbonate Remaining At 205°F
After 24 Hours At 50°F
Magnesium Hydrate Remaining At 205°F
Reduction By Boiling

FIG. 1. ACTION OF HEAT IN HASTENING WATER SOFTENING REACTIONS

Viscosity is the resistance which a fluid offers to shearing. The co-efficient of viscosity may be defined as equal to the tangential force required to slide a unit surface at unit velocity at unit distance from another surface with the fluid between.

Obviously, a large particle will settle more rapidly than a small particle because it contains a greater mass, and hence is acted upon by a greater force, in proportion to its surface. Considering a spherical particle whose density is greater than that of water, the maximum velocity with which it falls is given by Stokes' formula:

$$V = \frac{2}{9} \cdot \frac{D - d}{N} gr^2$$

in which V is the velocity, D the density of the particles, d the density of the water, g the acceleration of gravity, r the radius of the particle, and N the co-efficient of viscosity.

In a water softener the precipitated particles are of various sizes, and possible of different densities, but any given particle will fall through the water at a rate depending upon the viscosity, and it is therefore of interest to note how the viscosity of water changes with temperature, as shown in the following table by Thorpe and Rodger:

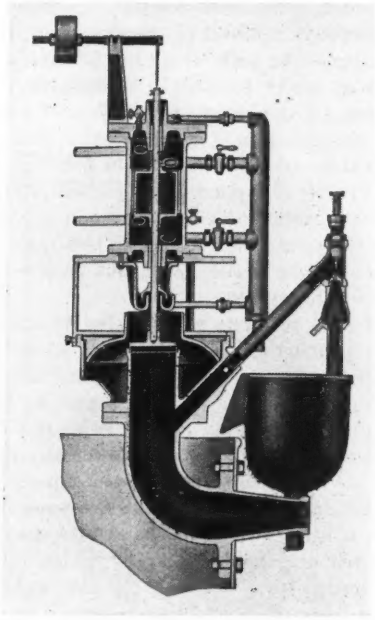


FIG. 2. CHEMICAL PROPORTIONER

Temperature, Degrees, F.	Co-efficient of Viscosity
32	0.01,778
50	0.01,303
68	0.01,002
86	0.00,798
104	0.00,654
122	0.00,548
140	0.00,468
158	0.00,406
186	0.00,356
194	0.00,316
212	0.00,283

At the freezing point, the viscosity of water is over six times as great as at the boiling point, while as between water at 68 deg. F. and water at 212 deg. F.. the increase in velocity of fall will be about four times.

Now consider how this applies in a water softener. Suppose we have a large tank full of absolutely quiet water. A particle of any given size will descend four times as far in an hour in hot water as it will in cold water.

Next, suppose we have a continuous softener in which the water is constantly flowing through the sedimentation tank. The rate of flow can be four times as great in a hot-process softener as in a cold-process softener without carrying particles of a given size to the pump supply pipe; or to put it in still another way, with a given rate of flow through the settling chamber much smaller particles can be separated out in the hot-process softener than in the cold-process softener. The further fact that the particles formed in a hot-process softener are larger than those formed in a cold-process softener renders the advantage of the hot process still greater, since the velocity of fall increases as the square of the radius of the particle.

It is therefore plain why the preliminary heating of the water, a feature which is peculiar to the hot process softener, gives more complete chemical reactions and more thorough removal of the resulting precipitates.

The completeness with which scale-forming matter is removed from water treated in a hot-process softener may be shown by the following analyses of water before and after treatment in a commercial installation. In considering these results, it should be borne in mind that a grain is 1/7000 of a pound, or 1/58,415 of the weight of a gallon of water. The small amount of solids remaining in the treated water from a hot-process softener does not form scale in the boiler, but gathers as sludge, which is easily blown out.

The chemical reagents must be fed to a softener accurately in proportion to the amount of water and to the impurities in the water, so that the treated water may not deposit scale on the one hand, or contain an excess of unused reagents on the other. For proportioning the reagents to the raw water supply, various mechanical arrangements have been devised.

In some softeners, the raw water flowing to the softener turns a water wheel or operates a tilting bucket which in turn operates dippers by which the reagents are ladled out to be mixed with the raw water.

In other softeners a certain portion of the water divided from the main supply by means of orifices or weirs, flows through chambers containing the reagents. In one such proportioner, the water in flowing through the reagent tank becomes saturated.

In another form, the water displaces the reagent from a tank, at the same time diluting that which remains in the tank. Means for adjusting the orifices progressively as the reagents become more and more dilute are therefore required.

None of these methods is well adapted for feeding chemicals to a hot-process softener, which should be designed for operation under a few pounds back pressure, since it is necessary to carry a few pounds back pressure upon the exhaust steam, in order to insure a temperature of at least 205 deg. F. of the treated water at all times. With the methods just mentioned, it is necessary that the chemical feeding equipment be enclosed within the steam space or else that the chemical and raw water, after being proportioned, be pumped into the softener against the back pressure. If the water wheel, or the tilting bucket, is enclosed so that the reagents can flow by gravity directly to the reaction chamber, steam finds its way into the chemical tank, where it condenses, diluting the reagents and rendering the feed inaccurate. The divided flow method involves an additional pumping of both the raw water and the reagent and is therefore complicated and expensive.

In still another arrangement the raw water is passed through a hydraulic motor, of the reciprocating or of the rotary form, which drives a small chemical pump.

The chemical proportioner used in one hot-process softener to regulate the feed of chemicals in proportion to the flow of raw water is a flow proportioner. The chemical to be fed to the softener is forced through an orifice by a pressure just equal to the differential pressure set up by the flow of the raw water through an orifice in the supply pipe.

To understand how the device works, refer to Fig. 2. Between two flanges in the pipe through which the raw water flows to the heater at the top of the softener is placed a thin orifice disk.

From the two sides of this orifice small pipes lead to the opposite ends of a cylinder containing a piston. The piston is thus acted upon by the differential pressure due to the flow of water through the orifice.

The vertical piston rod extends through water glands at each end of the cylinder. On the lower end of the rod is a valve disk, which closes over an opening through which a fluid mixture of the reagents is constantly being forced by a centrifugal circulating pump. The weight of the piston, rod and valve disk is counterbalanced.

The differential pressure acting upon the piston pushes the disk down upon and tends to close the opening, while a pressure builds up underneath just sufficient to balance the differential pressure. The pressure of the chemical solution is therefore directly controlled by the differential pressure resulting from the flow of water through the orifice in the raw water pipe. Through a simple pipe connection, this pressure acts directly at the chemical orifice, insuring an effective pressure on this orifice at all times equal to the differential pressure on the raw water orifice. Most of the chemical solution supplied by the circulating pump flows out from under the disk and through a strainer and thence back into the chemical solution tank. The proportioned chemical flows through the chemical orifice into a funnel, from which it is taken by a chemical feed pump, lifted to the softener and forced in against any back pressure that may exist in the latter. The back pressure in the softener thus does not affect the proportioning.

As the chemical, before escaping through the small orifice, is not in contact with air, no incrustation occurs therein; but to provide for dislodging any obstruction, a cleaning needle is so arranged that it can at any time be forced through the orifice by the pressure of the hand.

Besides being accurate, this arrangement has other advantages. Only one chemical solution tank is required, which is at the ground level, where it can be charged without hoisting of chemicals or inspected without climbing a ladder.

The motor which drives the circulating pump also drives agitating paddles in the tank. Milk of lime can thus be kept in suspension and fed as well as purely fluid reagents. The large saturator tanks necessary where lime water is used are eliminated and the difficulty due to the fact that lime water varies in strength according to temperature is avoided.

Solutions of caustic soda or sodium carbonate, lime

water, milk of lime, or any mixtures, are all handled equally well and fed accurately.

The chemical treatment is controlled by drawing a sample of the treated water from time to time and titrating with standardized solutions, the whole operation requiring about ten minutes. By locating the titration readings thus obtained upon a chart for correct chemical treatment, the operator sees at a glance what change, if any, is required in the amounts of the chemicals.

The hot-process apparatus illustrated in Fig. 3 is simple and compact. The open heater, with an oil separator attached for purifying the exhaust steam used for heating the water, is mounted directly over the reaction and sedimentation chamber. The water is heated to steam temperature by spraying it over trays, which also serves to release oxygen and other dissolved gases. It is then mixed with the reagent and falls directly into the sedimentation tank. The water does not pass through piping from the time when it is first heated until it has been through the sedimentation chamber, even the overflow receiving only settled water.

The precipitated matter deposits in the conical bottom of the sedimentation chamber, from which it can be quickly washed by the opening of a single valve. In order to eliminate convection currents, the hot water and the softening reagents are delivered at the top and travel slowly to the bottom from which the clarified water is drawn off by an inverted funnel. The precipitates formed when the water is first mixed with the chemical fall through the water below, securing a screening effect and gathering together the smaller particles. Precipitates are carried to the conical bottom of the tank, from which they are readily blown out by opening a sludge valve at the lower end or apex of the cone.

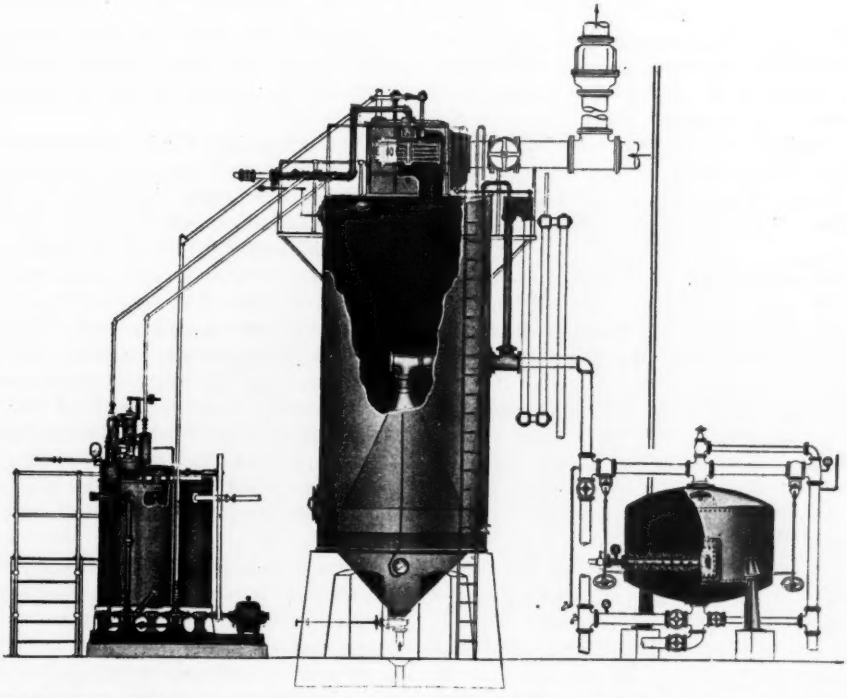


FIG. 3. HOT-PROCESS WATER SOFTENER COMPLETE WITH CHEMICAL REAGENT TANK, FLOW PROPORTIONER AND SAND FILTER

Filters

The removal of scale-forming matter at high temperatures by sedimentation is so effective that for many waters and plant conditions it is entirely practicable to dispense with filters. Many softeners are accordingly installed without filters and are successfully protecting the boilers from scale and corrosion, even though the softened water contains a slight amount of suspended matter. Other conditions demand the use of filters, for which a low-pressure sand filter is placed between the sedimentation tank and the boiler feed pumps or meter, the water flowing through the filter by gravity. These filters deliver a crystal clear water which contains no solids except those in solution and no mud-forming properties except the amount which is below the exceedingly low limit of solubility of calcium and magnesium monocarbonates, silica, etc., at the boiling point. This water will leave no troublesome deposit in the feed lines, pumps or meters and is particularly suitable for boilers operated at high ratings.

The filter is essentially a bed of fine sand resting upon a bed of gravel; embedded in the gravel layer are strainer heads or valves. The strainer valves are of a self-cleaning type, having a movable head or disk which rests upon the stationary part of the valve in such a way as to leave small openings or ports around the edge. In back washing, the water is admitted through the strainers in a reverse direction and lifts the disks or heads, increasing the openings of the ports to double the normal size, with the result that any particles of sand or other substances which may have lodged in the port during the filtering operation are released and carried out by the wash water.

The strainers may be screwed into a collecting and wash water distributing manifold, or into a diaphragm.

Embedded in the gravel layer is an air distribution system consisting of a main pipe with laterals, the latter perforated on the underside to permit the escape of air throughout the gravel layer. The air is used for loosening up the filter bed preliminary to back washing, the proper rate of air admission being controlled by an orifice in the pipe connection.

The filter chamber is connected to the softener through valves at the top of inlet and to the boiler feed pump from the bottom or outlet chamber. There is also a valved bypass from the softener directly to the boiler feed pump suction. The inlet and outlet of the filter are connected through hand operated gate valves to a waste pipe, to which a relief valve at the inlet also discharges. Finally, there is a connection to the outlet opening from a water supply, for back washing. A pressure gage is provided to show when the filter needs washing. Back washing is done at intervals, several times daily, the frequency depending upon the character of water. In some installations, more than one filter is installed so that it is not necessary to feed unfiltered water to the boilers while washing.

Hints on Refrigeration Practice---I

PURGING AMMONIA CONDENSERS AND CARE OF REGENERATORS. BY A. G. SOLOMON

FREQUENTLY engineers in charge of refrigeration and ice-making plants are more or less perplexed as to the proper means to be employed in purging the ammonia condenser. In a plant where an ammonia regenerator is in continuous operation and where proper precaution is taken, the purging of the ammonia condensers need be done but once a year. Just before the warm season begins, all the noncondensible gases should be blown out.

The noncondensible gases are the result of impurities that are allowed to enter the system. Air will get into the system at such times as the pressure on any part of the system is reduced below the pressure of the atmosphere.

When one or more of the ammonia compressors are operated on sharp freezers, it can easily happen that an engineer will become so interested in the lowering of the freezer temperature that he will allow the back pressure to fall below that which is actually required for the low-temperature work.

If the back-pressure gage shows less than 1 lb. pressure it is reasonable to expect air to be drawn into the compressor through the piston rod packing. This is especially true if the machine is operated at a fair rate of speed. The piston must travel far enough so as to reduce the pressure in the cylinder below the pressure that is in the suction line. This is necessary so that the tension of the suction valve spring may be overcome and the cylinder allowed to fill with vapor. A vacuum will exist in the cylinder for a short time just before the suction valve opens. Careful attention to the rod packing and its lubrication will prevent air entering at this point.

When it is necessary to pump out any part of the system for repairs or alterations, it is best to allow the coils that are to be pumped out to warm up as much as possible so that the ammonia will evaporate rapidly when the pressure is reduced.

Do not pump a vacuum of 10 or 20 in. and hold it with the compressor. If the coil to be pumped out contains oil and it is hard to get the ammonia out, lower the pressure to 10 in. vacuum, then shut off the coil and let the pressure build up again and then pump again. This may have to be repeated three or four times, but it is the best method as the chances of drawing air into the system are reduced.

After opening any part of the system be sure to pump out the air before turning in the ammonia.

Prevent air getting in and frequent purging will not be necessary.

Oil and moisture will cause decomposition of the ammonia and the resultant noncondensible gases will have to be blown out. Use little oil in the lubrication of the rods and compressor valves and pay strict attention to the emptying of all oil traps.

To purge noncondensible gases, first pump the entire low-pressure side of the system down to 5 lb. pressure. If the condenser pressure goes higher than is considered safe before all the ammonia has been sent to the condenser, stop all but one compressor and run that slowly during the final part of the pumping down. Next (with all the machines shut down), separate the ammonia condensers by closing the gas, liquid, and equalizing valves on each coil. Allow the cold water to circulate freely so that condensation is as complete as possible.

Then purge each coil separately. It may seem slow and troublesome but it is best to extend the purge line down and blow the gases into a pail of cold water. The noncondensible gases will form bubbles; but as soon as the good ammonia comes, the bubbles will disappear and a crackling noise will be noticed.

As the ammonia space in a double-pipe condenser is small, it is an easy matter to lose a lot of ammonia if the purging is not done with the greatest care.

Purging of the condensers during the summer should be avoided. It is most unsatisfactory to purge the noncondensible gases by simply shutting of one or two stands and after allowing them to cool, to blow them. The amount of ammonia trapped in the coil is very small and a great deal of it will evaporate and rise with the noncondensible gases and be lost through the purge valve.

REMOVING OIL FROM EVAPORATING COILS

DURING a recent conversation with an engineer in charge of a refrigerating plant, he asked me a number of questions, as follows:

"What is the best method of blowing oil out of the evaporating coils into the regenerator?

"What should be the relative pressure on coils and regenerator?

"Should the valve between regenerator and suction line when blowing oil, be closed entirely or just cracked?

"When regenerator is distilling, should same valve be opened wide or just cracked?"

With reference to his first question, I proceeded to impress upon him the fact that the pipe connections to and from an ammonia regenerator or purifier should be given serious thought. It is common practice to heat the charge in the regenerator to a high temperature and allow the evaporated ammonia to pass to the suction line or other part of the low-pressure side of the system. While doing this, the valve between the regenerator and the suction is partly open.

If we consider the low temperature necessary to evaporate the pure ammonia at suction pressure, we will readily see how easily the impurities can be carried into the system instead of their remaining in the regenerator.

The pure ammonia, separated from the impurities, should pass to the condenser or some part of the high-pressure side of the system instead of to the low-pressure side.

The accompanying sketch, Fig. 1, will show the best and safest way to connect up a regenerator. Whether the regenerator is vertical or horizontal will not affect the pipe work. If of the horizontal type, it should be inclined a little so that the oil and impurities will flow toward the drain valve.

The line through which the pure ammonia is to escape is extended and connected to the equalizing line of the ammonia condenser. A check valve located in this line and close to the condenser will act as a relief and also as a check to prevent liquid condensing and flowing back from the condenser. A tee is placed at a convenient point and a valve so located that the ammonia pressure on the regenerator can be lowered to that of the suction before the impurities are drawn off.

The regenerator must be provided with a pressure gage and safety valve as well as the glass gage. The outlet of the safety valve can be piped into the low-pressure side of the system unless the inspection laws of the state or city say otherwise. The safety valve must be set to open at a pressure of about 10 lb. higher than the usual condenser pressure carried.

Try the safety valve at least once a week so that it is known that it will operate if called on to do so. To test, allow the regenerator to fill with saturated vapor from the suction line, then close the valves on the lines leading to the condenser and the low-pressure side of the system. Apply the heat and watch the pressure gage. As the pressure rises, keep one hand on the valve in the line between the regenerator and the suction. If the safety valve does not open when it should, open the valve just a little and allow the pressure to fall. There is not the slightest danger in testing the safety valve in this way.

The inlet to the regenerator is connected to as many parts of the system as deemed necessary to remove impurities. The oil traps on the discharge lines and on the suction lines can be emptied at the regenerator. The bottom manifold of the ice tank coils, the drain of accumulators and the lowest points of direct expansion piping should all be piped to the regenerator. If any type of shell brine cooler is in operation, its blowoff should also go to the regenerator.

In a plant where sharp freezers are handled as well as ice tanks and cold storage rooms the filling of the regenerator is made simple owing to the two back pressures carried.

A line, provided with a valve, is extended from the top of the regenerator to the suction line that connects with the coils of the sharp freezers. This will be called the low back-pressure line. The high back-pressure part of the system is the evaporating coils and suction line that connects with the ice tanks, cold storage rooms and all places where ordinary temperatures are maintained.

In emptying any part of the high back-pressure side of the system into the regenerator, the pressure on the regenerator is lowered by opening the valve leading to the low back-pressure suction line. This will give a pressure difference of at least 10 lb. which will allow the oil and other impurities to flow into the regenerator.

The traps on the discharge side of the system can

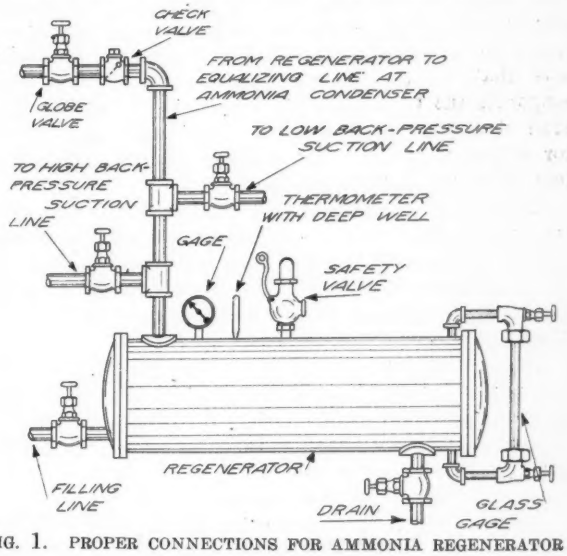


FIG. 1. PROPER CONNECTIONS FOR AMMONIA REGENERATOR

be emptied into the regenerator by relieving the pressure into the high back-pressure suction line.

To fill the regenerator from points of the low back-pressure, or sharp freezer side of the system, it will be necessary to increase the pressure on the part to be emptied. This is done by closing the necessary valves that connect with the low back-pressure suction line and allowing the expansion valve to remain open. The pressure gage on the regenerator will be in connection with the coil or trap that is being drained as the connecting valves will be open to allow the regenerator to fill. When the gage shows 10 lb. above the pressure of the high back-pressure suction line, just crack the valve and allow the gas to escape into the high back-pressure suction line.

The difference in pressure between the regenerator and the part of the system being drained should be great enough so as to cause a flow. This difference will be a little greater when cold traps are being emptied than if the traps or manifolds are warm. The flow of oil and other impurities is slower with low temperatures. A pressure difference of 10 lb. will be found sufficient for all purposes.

After the gage glass shows the regenerator to be

about one-half full all valves are closed except the one on the relief line to the condenser. This valve should never be closed unless at times when it is absolutely necessary and when testing the safety valve.

Next, the heat is applied and the temperature slowly raised. The pressure will increase rapidly as the evaporating ammonia will expand as soon as the heat is applied. When the pressure in the regenerator reaches condenser pressure, the check valve will open and the ammonia gas will escape to the condenser.

At this pressure the impurities will not carry over with the pure ammonia unless the regenerator is allowed to become quite hot (200 deg. F. or over).

A thermometer is a convenient instrument to have, inserted in a well that reaches into the interior of the regenerator at a point where the temperature of the impurities can be read.

Refer to the ammonia tables and the evaporating temperature of ammonia will be found to correspond with the pressures. Raise the temperature of the regenerator not to exceed 5 deg. F. higher than the temperature that corresponds with the pressure. This will evaporate the pure ammonia slowly, but it will do the kind of a job that is wanted. Hold this temperature for a length of time that will be decided on after a little practice and observation.

Next shut off the heat and just crack the valve on the line leading to the suction enough to relieve the pressure. Leave this valve open only long enough to see the pressure gage begin to move downward. As soon as it is shut, the pressure will again go up to that of the condenser.

Next, drain the regenerator. The gas that will be left is hot and will have so little weight that there will be no loss of ammonia.

Allow the regenerator to cool before attempting to fill again.

Nightmare, Ahoy!

By John Wallace Shaw

IT WAS twelve forty-five when he flopped into bed, after a trial with a cranky crosshead, and he wondered if, now that he thought the job done, they would let him alone 'til next day's work had begun. He closed his tired eyes, with a comfortable yawn, intending to sleep like a log until dawn, and it was but seconds, he gave me his word, until he was dreaming a thing most absurd.

Old Morpheus opened the engine-room door and the engineer's eye took a glance at the floor. What manner of floor did those tired eyes behold? Why, the whitest of marble and inlaid with gold. He pulled off his shoes, with his heart all a-flutter, and tried once to speak, but no word could he utter. He donned the felt slippers he found at his feet and a guide led him off to a most regal seat, which commanded a view of the marvelous room, all lit with a splendor that dispersed the gloom. The poor engineer could but just gaze in awe at the spotless prime mover and things that he saw. 'Tis a wonder his eyes did not pop from his head, as he afterwards most confidentially said.

The engine was silver and all lagged with gold. Not a nut or a stud that looked dirty or old. There wasn't a sign of a knock or a pound. Why! the whole pretty outfit was minus a sound. And strangest of all, as he soon was informed, the bearings and journals had ne'er even warmed, in spite of the fact that they here used no oil, their floor, their hands or their engine to soil.

"And now," said the guide, "there is one other thing, and then I will you to the boiler-room bring. We ne'er have the trouble you fellows all do. We leave here at night and we know our work's through. No packing, no changing of valves in the pump, no cussing when hard-working hands get a bump. We're happy, contented, we're well paid and gay and all wish a year constituted a day. Can *you* say as much when you're home in your bed?" and the engineer mournfully shook his poor head.

"This is the boiler-room," next spoke the guide. Once more the engineer looked and then sighed. A marvel of cleanliness. Casings of brass that covered the boilers spelled nothing but class. In vain the poor engineer looked for the fuel. There was nothing in sight—no, not even a tool. Here, too, the white floor was clean as could be; and no water-columns did he ever see. He wandered at will through the length of the place, and each added step brought a grin to his face. "Say, guide," he said, "this fine place cannot be what you called it just now when a-speakin' to me." "That's just what it is, friend, for fuel we burn air and it does not need fire tools or coal scoops or care. It sure boils the water and never leaves soot and gives us our steam with a little to boot. We carry but six thousand pounds by the gage, but that's quite enough in this unadvanced age."

The tired engineer wiped the sweat from his brow, not caused by wonder, but nervousness now, and walked to the wall, where he spied a brass shell, tiny and bright, and asked, "What the h—— is this little contraption? Your feed-water heater? And is it a hoggish, old soda-ash eater?" The intended sarcasm was lost on the guide, who knowingly smiled and then calmly replied, "No, that is our feed pump. It works like a charm; and right over there's the low water alarm." The engineer followed the guide's pointed finger. This queer curiosity just made him linger. A structure of wires and of tubes all entwined, it nearly took toll of his tottering mind.

The guide then explained that this shining device was very efficient and very precise. He also explained that, at 'most any time, it was due to ring out with its most pleasing chime. So both of them waited and then, sure enough, with a jangle of bells that was jarring and rough——

The telephone tinkled, his feet hit the floor, he pulled on his clothes and then slammed the back door. With a short muttered cussword at Fate's time-old prank, he went back to the mill to cool off a hot crank.

The Sweet Young Thing was being shown around the power house. Stopping at the winding department, she asked: "Oh! what's he doing?"

"Winding armatures."

"Why, I didn't know they run down."

"Er—yes, yes; some of them require rewinding."

Unusual Conception of Slide Valve Travel

In the March 1 issue, page 300, I have noted the article "Unusual Conception of Slide Valve Travel" and would like to differ with some of the views entertained by Mr. Winans. I do not think he has the right meaning for the word eccentric.

Referring to Fig. 1 we have two circles, the smaller one representing the shaft and the larger the same size as the outside of the eccentric shown in Fig. 2. In Fig. 1 both circles are drawn with the same center and hence are concentric.

In Fig. 2 they are drawn with two different centers A and B and for that reason they are called eccentric. The distance between the centers, ½-in. in this case, is the amount of eccentricity.

On the engine eccentric the center B revolves around the center A as indicated by the dotted circle BC and the valve travel is equal to the diameter of this circle which is twice the distance from A to B and is twice

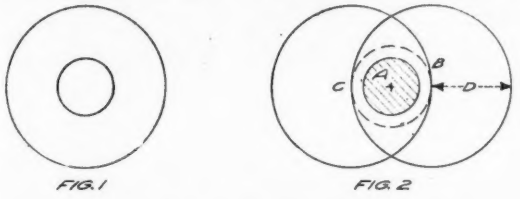


FIG. 1. CONCENTRIC CIRCLES
FIG. 2. ECCENTRIC CIRCLES ILLUSTRATING THROW AND TRAVEL OF ECCENTRIC

the eccentricity of the eccentric. This distance is also equal to the distance D which he knows is the valve travel.

Mr. Winans also says that it is an error to presume that an eccentric is only a shaft with an enlarged crankpin. Taking the point B as a center for the large circle or the outside of the eccentric, this large circle would be a crankpin larger than the shaft which is indicated by the small circle which disproves his idea.

OTIS E. HOWE.

Regarding the Conception of Slide Valve Travel, by Roy R. Winans, in the March 1 issue, his method is correct and may be used for graphical solutions; but in practice, would it not be simpler to measure the distance between the center of rotation and the center of the eccentric? This is, in fact, the eccentricity, or the amount the center of the eccentric is eccentric with regard to the center of rotation. The valve travel will then equal twice the distance between the center of rotation and the center of the eccentric, or twice the eccentricity.

R. D. JUNKINS.

Technic of Mechanical Engineering as Applied to the Refining of Crude Petroleum

It seems, indeed, unfortunate that any engineer should possess such misleading information as is evidenced by C. O. Sandstrom's article pertaining to "Faulty Engineering in Oil Refineries," appearing in the mid-February issue of Power Plant Engineering, and it is even more unfortunate that, possessing such a limited amount of information on his subject, he should attempt to belittle the efforts of thousands of qualified mechanical engineers, who are spending their time for the betterment of one of our greatest industries.

As a mechanical engineer who has for 15 yr. followed the production and refining of petroleum in six different states and who, during that time, has lost no opportunity to apply the most modern methods consistent with economic operation to his work, I take unqualified issue with 99½ per cent of Mr. Sandstrom's statements.

Personally, I have never met a chemist whose conception of a mechanical engineer consisted of a draftsman and, while such men may exist, I am glad that we have very few in the oil business.

While the actual refining of crude petroleum is, no doubt, essentially a chemical process, it is in the treatment of the refined products, such as benzine, kerosene, lubricating oil, asphalt and paraffin wax, that the true oil chemist shows his ability, and it is in the actual refining operation that the mechanical engineer has his opportunity.

For many years prior to 1916 the refineries had no trouble in supplying all of the gasoline demanded, and consequently were not greatly concerned with the problem of so increasing the efficiency of their plants as to produce a greater quantity of the light oils than was needed by their particular market and, due to the rapid evaporation of gasoline in storage, it certainly was not good business to have a great amount of this product on hand. Why, then, should refineries introduce processes in still operation which would do nothing but increase the yield of a product which was already a drug upon the market? It might be well to state here that it is a physical impossibility to obtain the lubricating distillate from which lubricating oils of various grades are made, and the wax distillates from which paraffin wax is made, without first taking off the lighter fractions which constitute the gasoline and kerosene.

At the time of this country's entry into the World War, the demand for gasoline suddenly became tremendous, and every plant in the country bent every effort to produce more of this product. A little investigation will disclose the fact that since that time there have been more improvements designed and installed by mechan-

ical engineers, with the hearty co-operation of the plant chemist, than in any other industry in the world.

It would be foolish to state that we have arrived at a state of perfection, and it is equally foolish to condemn the entire refining industry upon facts gathered from a few plants.

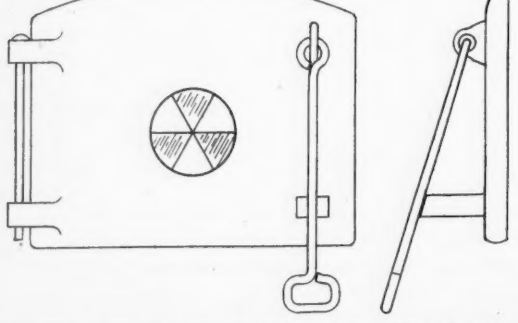
Being one of the industries which was under direct government control during the war, these plants were required to make the same fuel report as any other industry, and while I know of many plants operating with a sinful waste of fuel, I know of scores who are using the most modern furnaces designed for fuel oil; using economizers for preheating the crude oil, and in every sense operating as efficiently as any power installation in the country.

Any engineer familiar with the distillation of crude oil knows that the vapor lines referred to are not "ridiculously large," but are so designed to prevent the cracking of the vapor so detrimental to the production of first-class gasoline. As to the submerged condenser, I do not understand Mr. Sandstrom's statement as to its efficiency. The word efficiency is a comparative term, but if he means that it will not radiate the same amount of heat as other types, he is correct, and, not being familiar with this particular industry, probably does not know that it is not desirable to bring the condensed vapor to a very low temperature, due to the congealing of the heavier oils in the pipe.

There is no engineer, mechanical, chemical, or a happy combination of the two, who can design efficient apparatus for handling all grades of crude oil, for the simple reason that practically no two grades of crude are the same. If you will look up the records of the thousands of engineers who are engaged in this business, you will satisfy yourself that the industry is at last getting its proper protection. JOHN S. BLAIR.

An Improved Fire Door Handle

IN THE average plant, the boiler furnace firing doors are not equipped with handles, with the result that they cannot be opened for inspection or cleaning without danger of burning unless the shovel or some other object

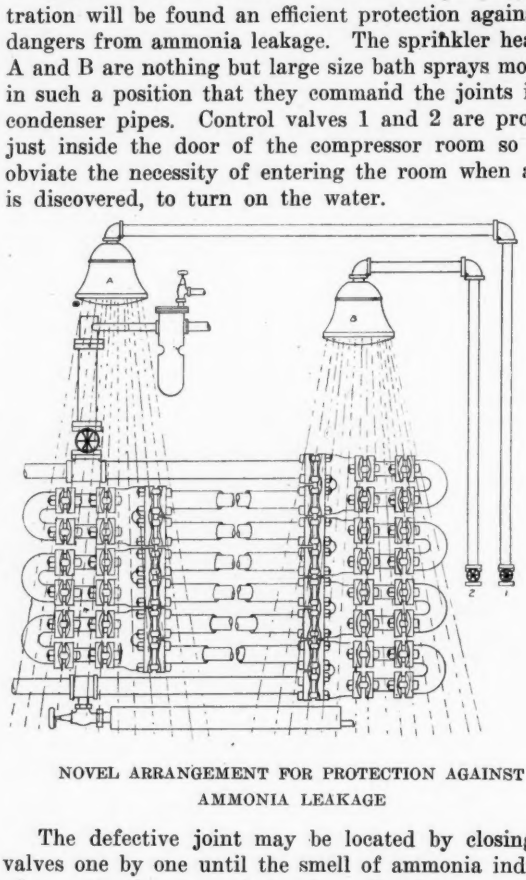


SHOWING APPLICATION OF HANDLE TO FURNACE DOOR

is used to lift the door off its latch. In our plant, we found this to be a disadvantage in giving proper attention to the fires, consequently we equipped our doors with reach handles as shown in the sketch, the lower end or handle being covered with a piece of rubber hose. These handles were made a bit long purposely, so that the doors could be opened while one stood a foot or two away, and was not immediately exposed to the heat of the furnace. M. A. SALLER.

Emergency Protection Against Ammonia Leaks

THE ARRANGEMENT shown in the accompanying illustration will be found an efficient protection against the dangers from ammonia leakage. The sprinkler heads at A and B are nothing but large size bath sprays mounted in such a position that they command the joints in the condenser pipes. Control valves 1 and 2 are provided just inside the door of the compressor room so as to obviate the necessity of entering the room when a leak is discovered, to turn on the water.



NOVEL ARRANGEMENT FOR PROTECTION AGAINST AMMONIA LEAKAGE

The defective joint may be located by closing the valves one by one until the smell of ammonia indicates where attention is needed, when all other sprays may be turned off and the leaky joint repaired.

OTTO DORTHEN.

Filing Magazine Articles

FOR 40 YR. I have been in the power plant game. For about the same length of time I have been reading technical journals and trying to find a way to file clippings or otherwise preserve papers on subjects that I was interested in or felt that I might want to look up, but without producing a system that was entirely satisfactory.

First, I tried pasting clippings in a scrap book. This was unsatisfactory and soon discarded. Then we tried removing the advertising matter and binding. This was interesting pastime, but did not prove satisfactory. The next idea was to file the issues and try to keep the indexes, but in the course of a few years the attic became crowded. Sometimes we spent our nights for a week or two trying to find an article on a subject in which we were interested. We finally called a drayman and had the whole lot hauled to the junk dealer.

Next, we bought lumber and made a lot of pigeonholes about 12 by 18 in., cut out the sheet containing

matter I was interested in, rolled them up, and put them into the pigeonholes. I followed this up until I had it pretty well filled. Some time when I have the leisure I am going to investigate the contents of that filing rack: I imagine I shall find it very interesting.

Next I got a loose leaf book cover and filed the sheets containing interesting matter, but I never did like to use loose leaf books where it could be avoided. They look out of proportion when the rings are full; the rest of the cover looks as if it had nothing in it. Lastly, I am trying filing the sheets in a letter file, each subject under its first letter, as, "Synchronous Motors" under "S." This looks like it might be partly satisfactory. It will enable me to take out all the clippings on any subjects. Furthermore, it is easy to discard obsolete matter. It is best not to do too much clipping, otherwise the files become bulky and make it hard to find what you want.

In many cases, up-to-date books that cover a subject fully are the best, but it is hard to keep a book up-to-date, and this is where technical papers excel.

J. O. BENEFIEL.

Engineers' License Law

I AGREE with Power Plant Engineering readers that we need some kind of law to weed out the incompetent from the real engineers, but believe that the weeding out process could be better accomplished by a national fuel inspection law. Under its provisions, the coal mine operators should be compelled to have their coal analyzed by the Bureau of Mines, and the Bureau of Mines would state the number of pounds of water different grades of coal could evaporate. Then a power plant owner, by buying coal guaranteed to evaporate a certain number of pounds of water per pound of coal and by reading his coal bill and feed water meter, could tell what kind of engineer he is employing.

JOSEPH J. ZLABIS.

Absolute Zero

IN MECHANICAL refrigerating, we have a large range of temperatures to deal with; but the one that is not the same everywhere, according to different writers, is absolute zero.

Matthews says: "Could all of the heat be removed from a substance, the resulting temperature would be absolute zero, or about 466 deg. below our present Fahrenheit zero."

Then again, in "Audel's Answers on Refrigeration," we get this: "Absolute zero is about 460 deg. below zero, or the point where all motion of the molecules ceases."

Now, along comes Swingle with this one: "Absolute zero has been fixed by calculation at 461.2 deg. below the zero of the Fahrenheit scale."

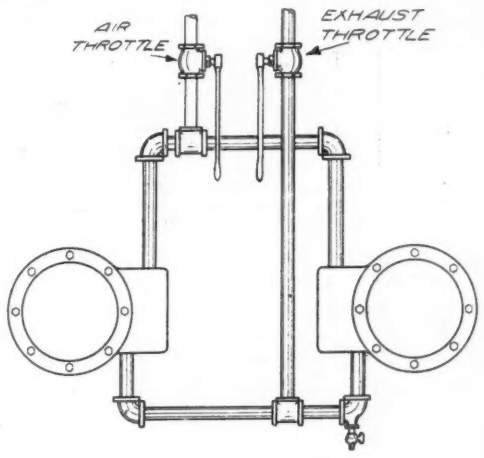
Siebel says: "The real zero point of temperature, that is, that point at which the molecules have lost their motion, the energy of which represents itself as heat, is supposed to be, and in all probability is, over 460 deg. below the zero of the Fahrenheit thermometer."

From the foregoing it is plainly to be seen that absolute zero, like the actual air we breathe, is not the same all over. So I ask, what is absolute zero and why can't we get busy and have it the same all over? Between Matthews and Audel there is a difference of 6 deg.; between Matthews and Swingle, 5.2 deg.; between Audel and Swingle, 1.2 deg.; between Matthews and Siebel, 1 deg., and between Swingle and Siebel, 0.2 deg. In one place in his book, Siebel says 460 and in another place 461. A single degree one way or the other doesn't look very big on paper, but get them into practice and watch the results.

HAYMAKER.

Preventing Freezing of Engine

THE ARRANGEMENT shown in the illustration was used to prevent an engine from freezing. Compressed air was used for operating, instead of steam. The exhaust pipe was extended as shown and was provided with a



ARRANGEMENT OF PIPING TO PREVENT FREEZING

throttle valve. The regular throttle valve was left open and starting and stopping was accomplished by means of the exhaust throttle valve.

O. M.

Reading the U-Tube Draft Gage

THERE HAS been much said about the U-tube used as a draft gage, but I do not agree with the methods of measuring the amount of draft indicated.

My contention is that the draft is the rise of the water in one leg from 0 point or the fall in the other leg from 0 point, not the rise in one leg plus the fall in the other leg.

Draft is produced by the difference between the weight of a column of hot gases contained within a chimney and the weight of the same bulk of cold air.

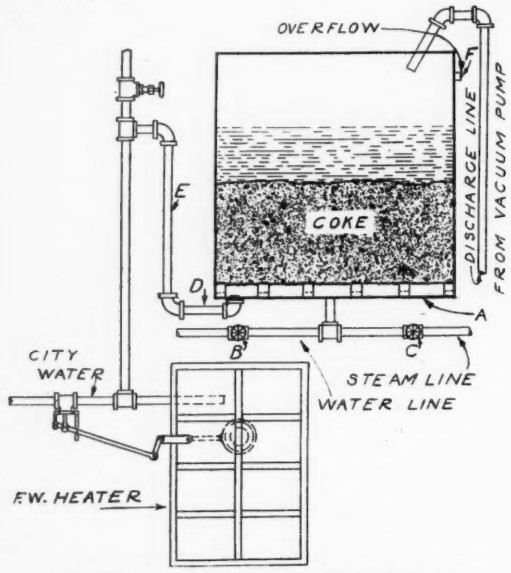
When the hot gases pass into the chimney they have a temperature of 400 or 500 deg. F., while the air outside the chimney has a temperature of from 40 to 90 deg. F. Thus, when we connect one leg of our U-tube to the chimney and the other to the outside air, it causes an unbalanced pressure in the two legs, due to the lighter hot gases in the chimney and the cooler atmosphere of the outside. The difference in the height of the water in our U-tube is the draft in inches of water.

M. W. CARTEE.

SOME MEN try to be good fellows by talking—and knocking all the other fellows.

An Easily Made Condensate Filter

THE FILTER illustrated has been in use about 6 mo. and has enabled us to save about 50 per cent on boiler compound. It consists essentially of a galvanized iron box 3 ft. each way, in the bottom of which are fastened pieces of 2 by 4-in. wood. A piece of copper wire screen 3 ft. square is fastened on top of the wood strips, using smaller strips to hold it in place. Pipe connections are made as shown and the box is half filled with broken coke. In operation, water enters at the top from the vacuum pump discharge and passes to the open heater through pipe D.



CONDENSATE FILTER AND CONNECTIONS

When the filter becomes dirty, the valve B in the ¾-in. steam line is opened long enough to heat the water in the filter and cause the oil to rise to the surface. Valves B and E are then closed and valve C in the ¾-in. city water line is opened, raising the water level so that the oil may be skimmed off through the overflow F.

L. T. McCOY.

Notes on the March 1 Issue

IN LOOKING through the March 1 issue, I was much interested in "Starting Up After a Shut-Down," by L. Williams, on page 298. This lesson in quick-wittedness is worthy of note. An engineer in a 10-hr. plant may not fully appreciate the necessity of speed; he has daylight to work with or by, but to be left in darkness means a different story.

It is simpler in a way to control the hydro station in a shut-down than a steam station, and right here will appear the necessity of a separate lighting unit—either storage battery or other means. In the hydro station, the governors close the gates to no load conditions, and if a proper pressure system is in vogue, a mechanical drive will be keeping sufficient pressure to operate at least one or two governors; but in a steam station of a few thousand kw., perhaps from 5 to 10 boilers will be in operation. Stokers will be running, forced and induced fans will be tearing along, and steam will be within 10 lb. of blowing.

Then bang! bang! The breakers all go out; the emergency trip works on the turbine; the synchronous motor exciter set goes out of business; the lights all go out, and then the steam reaches the blowing point and 10 or more safety valves blow! If the exciter set is of the duplex system and has a turbine all ready to pick the load when the motor lets go, and if the lights are, or can be taken from this source, a good bit of our trouble is over; but they are unfortunately not of this pattern, so we are in the dark, and no exciter on the d.c. bus.

Just a minute. The telephone has been ringing for 5 min. Guess we are in shape now to answer it.

"When do we get lights again? This is the Climax Moving Picture House."

By this time we've got the other bus working and lights on, so the moving pictures can again go on; and we solemnly vow that we will try to get a little turbine unit of 10 or 15 kw. just for station lights.

Now for "Economizer Operation," by Receiver, page 301. The economizer problem looks good and invariably figures immense profits. I have had economizers that served thousands of horsepower; in fact, I have now three economizers that were intended to serve thousands of boiler horsepower, but—how much power does it take to operate the induced draft?

Where do we buy economizers for $4.60 per hp. erected, flue and draft equipment complete, steam piping and extra water piping thrown in?

I could use, at the present time, about 450,000 lb. of water per hour at 260 deg. F., but I can't get it. If Receiver can duplicate these conditions in his plant or if the conditions are his own, they certainly are superb, but he must try to figure to put in tubes and headers nights and Sundays so as not to cut the service of the economizers or the 37 per cent will look like 30 cents.

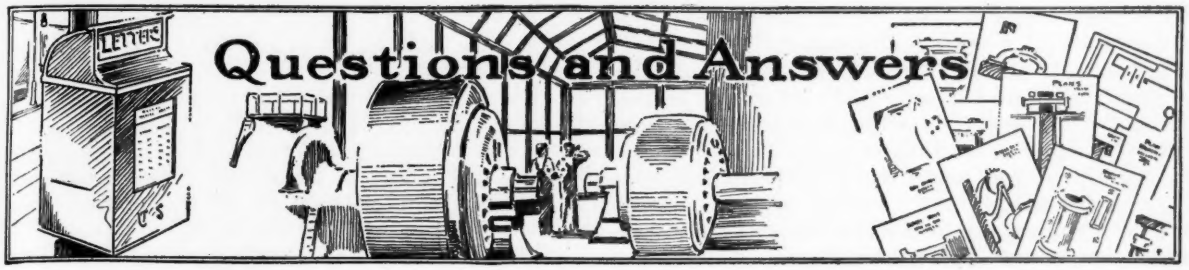
Under "Steam Traps," H. W. Rose recommends pitching steam pipes back to the boiler. Of course, we know the steam pipe comes out of the top of the boiler and possibly may drain back; but we also know that steam traveling at the rate of a few miles per minute, more or less, will take the water along with it. So we pitch the pipes away from the boilers.

Did you ever steam up a house boiler, single pipe system, in a hurry and notice how fast the water comes back to the boiler—not? Well, water runs back just the same way in a high pressure plant. More than one poor old engine has had its head blown off from the "back to boiler" idea.

If you pitch the pipe toward the engine or turbine, the water of condensation will flow constantly and be taken care of; but if you pitch it back, it will accumulate and then come in a mighty slug. This is the experience of an office that supervises 100,000 hp. or more. I agree that lines be taken from the top in most cases.

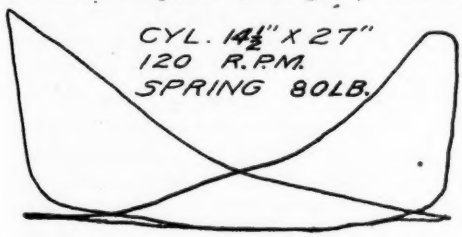
TOM THUMB.

U. S. CIVIL SERVICE COMMISSION announces examinations, April 20, for marine engineer, mechanical engineer and electrical engineer, to fill vacancies in the office of the Chief of Transportation Service, War Department, for duty at Washington, D. C., and throughout the United States, at $2400 to $4000 a year. Apply for Form 2118.



How Can Wire Drawing Be Eliminated?

THE ILLUSTRATION shows an indicator diagram from the high pressure cylinder of a 14½ by 24 by 27-in. Lentz engine, 80-lb. spring, 120 r.p.m. I would like to know how to improve the diagram, what steps to

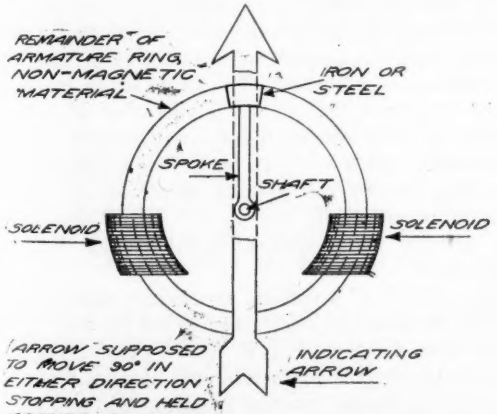


HOW MAY THIS CARD BE IMPROVED?

take, and how to get rid of the wiredrawing effect in head end. All valves on the steam line are wide open. TOM JONES.

Automobile Direction Indicator Problem

I HAVE a question to ask readers of Power Plant Engineering. A friend has a patent on an automobile direction indicator using a hollow electric solenoid. The coil is wound around a hollow spool with an armature ring to be drawn down through it by magnetic lines of force reaching 90 deg. around a circle to an attractive



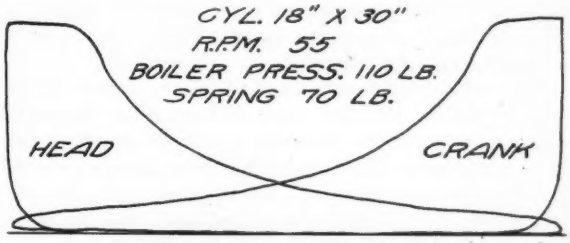
PROPOSED ARRANGEMENT OF AUTOMOBILE DIRECTION INDICATOR. WILL IT WORK?

piece of metal inserted in the armature ring. I suppose that it was designed or patterned after, or to work on the order of a series trip coil used in an oil circuit breaker.

I claim that the few magnetic lines of force that could reach the attractive body around a circle 90 deg. would be too weak to accomplish the desired results, or that the solenoids would have to be so powerful as to be impractical; or if he should employ an armature of all attractive metal, that the magnetic lines of force through the center of the core or spool would have a tendency to grip and hold the armature ring without moving it in a circular direction. I would like to hear from some of the readers on this subject and a way to accomplish the desired results, if practical, with this design of coil and armature ring. M. H. M.

Why the Knock?

WE HAVE a Corliss engine that is causing us some trouble, and I cannot find the cause. This engine has been run only 2 yr. It had sectional rings on the piston until a short time ago, when the springs broke down and we put on a set of snap rings, and ever since we put the snap rings on it takes spells of knocking in the cylinder. The knock is heavy and loud and, as best I can



THIS ENGINE KNOCKS. WHY?

tell, it seems like the piston bounces or jumps and strikes the top of the cylinder, as the jar seems to be all on the top of the cylinder. The knock comes just as the head end steam valve opens. Sometimes the engine will run several hours without a sound and then will start in and knock for several minutes, then quiet down and run smoothly. I cannot find anything wrong and I think the cards are good. J. L. S.

Comments on Questions and Answers

ON PAGE 258, Feb. 15 issue, W. L. S. has some questions which are followed by answers. I wish to make comment on some of these answers.

In question 12 is asked whether there are any condensers made that do not require a vacuum pump. He says that a barometric requires no vacuum pump, but that it does require an air pump to remove noncondensible gases. Now this condensor does not require an air pump; in fact, there are a lot of them without any pump. Of course, we know that with a large installation and

where they must have all the vacuum possible, air pumps are used, but they are not a necessity.

Question 13 reads: "With same size radiation, which is the more effective, a one-pipe or a two-pipe heating system?" The answer says that it depends to a great extent on the size of the plant; that in small plants the one-pipe is more used. This would depend on what is considered a small plant. In some houses, a one-pipe system is used as also in some apartments and dormitories; but in most places today they are putting in a two-pipe system and, while it costs more to install, better results are obtained. Circulation is faster, there is not the condensation going back in the same pipe, and there is not as much trouble with air pockets.

In question 17 is asked whether there is any other way to change the speed on a Corliss engine than to change the size of governor pulley or its driver? The answer is that it can be changed by lengthening or shortening the rods connecting the governor to the valve gear. Now, if this adjustment was not too great, the governor would control the point of cutoff, but not the same as before the rods were changed. No governor is made or adjusted so that it will be equally effective at all speeds or when in any position, or all positions within its range.

Slight changes in speed may be obtained without very harmful effect, but the sensitiveness will be affected. All governors and levers are designed to give the greatest sensitiveness at a certain speed with all parts in a certain position.

If the position of any of the levers be changed by adjusting the length of the rods, a change of position of the governor will be necessary to bring the levers to their original position, hence the relation of governor and lever have been changed.

Care must be taken to see that with governor at extreme height the knockoff cams will not allow the valve to open. Also, with governor at lowest position, the safety cams must hold crab claw from hooking on to valve.

Question 25: "Why is middle sheet fitted between the two end sheets?" The answer is, "Merely a matter of convenience in construction." My reason for this is that the inside sheet is placed as it is to prevent fire cracks in front end of this sheet, as it would leave the edge of the plate exposed to cold air entering through the fire doors. Some engineers say that the sheet is put inside to prevent a pocket, but you have a pocket in the front or middle sheet anyway. I had charge of two boilers at one time where both had been bagged in the front course. W. L. N.

Bearing and Eccentric Trouble; Steam Turbine Losses

IN ANSWER to X. Y. Z. in your issue of March 1, the valve has too much "lead" on the crank end. The valve rod is too short if the valve gear is of the direct acting type.

The following computations are by slide rule, and of course contain a small margin of error, but are correct in the larger aspect. The high-pressure cylinder is 29¼ in. diam. = 670 sq. in. area and the low-pressure cylinder is 46 in. diam. = 1660 sq. in. area, the ratio being 2.475 to 1. The number of expansions this engine should make, based on PV = a constant, is the square of the ratio or $2.47^2 = 6$.

If we assume that we are to expand the steam down to the exhaust line which normally will be about 2 lb. above atmosphere, we have $14.7 + 2 = 16.7 \times 6 = 100$ lb. pressure absolute at the throttle. Steam, however, is rarely expanded below 4 lb. effective pressure in a compound engine, which gives us $16.7 + 4 = 20.7$ lb. abs. $\times 6 = 124.2$ lb. abs. (110 lb. gage) in the high-pressure cylinder, cutoff occurring at 0.4 stroke nearly. Judging from the diagram submitted, this will call for 125 to 140 lb. pressure at the boiler.

From the diagrams, it is evident that the low pressure is not only not producing any power, but is actually producing negative indicated power plus the friction of low-pressure reciprocating parts. I, therefore, suggest taking down the low-pressure connecting rod and valve and running the high-pressure side as a simple engine.

The only objection I can see to this is that it would lower the receiver pressure and consequently the compression, but it will certainly save a great deal of steam.

The fact that the pressures change from positive to negative at about half stroke probably has something to do with the heating of the main bearing and low-pressure eccentric. ROY R. WINANS.

X. Y. Z.'s ENGINE TROUBLE has come under my observation in the March 1 issue of Power Plant Engineering, page 304, and in reference thereto I would like to have seen an indicator card of the high-pressure cylinder as well. However, to analyze these troubles roughly, I will first state that the work between both the high- and low-pressure cylinders should be as equally divided as possible. The low-pressure main bearing trouble could be due to engine out of line or either too tight or too slack in adjustment, oil ways clogged, not enough oil being fed the journal, improper oil being used or an overloaded bearing.

The eccentric trouble is possibly due to being out of line, straps too tight, oil grooves choked up, improper oil being used, not enough being fed them or most likely over loaded caused from valve stems being too tightly packed, improper setting of the valves or an improper lubricating oil being used which is causing the valves not to act freely. This would throw quite an additional load upon them, and by following the valve setting's marks or the rules specified by the builder as to the lap and lead, assisted by an indicator, all trouble should be eliminated.

As to W. P. C.'s turbine experience, also related on page 304, it certainly is unfortunate for the readers of an article of this nature that W. P. C. was not a bit more specific, especially as to the kind and name of his turbine. Before going deeper into the problem, it is well that the fact be considered as to whether or not the turbines are correctly balanced or out of balance, and especially the vibration feature, which should not be carelessly neglected; furthermore, the bearings, oil rings and packings. The packing connections, if sealed by water or steam, should receive careful attention at all times, and so in a general way I will take a random shot with the idea that through some of my suggestions and the limited

information I have to base my opinion upon, relating to the case, the trouble may be located.

There is a continuous drop of pressure from one end of a reaction turbine to another; mechanical clearances beween the rotating buckets and the casing, also between stationary buckets and drums, should at all times be of considerable importance owing to the fact that these clearance areas form means for considerable leakage losses. Radial clearances should be made as close as good mechanical operation permits. Small clearances are of more importance in the first drum than in the succeeding ones, owing to the small bucket heights and greater steam density. Mechanical clearance should be sufficient to allow for stretch of buckets, also drum, when subjected to centrifugal forces at high speeds and to expansions due to the effect of temperature changes of the moving and stationary parts. Leakage losses encountered in the first drum usually are from 4 to 7 per cent; in the second, some claim, from 3 to 6 per cent; in the third drum, from 1 to 2 per cent. Lower values call for close clearances. Leakage between the balancing piston and casing is usually from 5 to 8 per cent for the first piston, some claiming less; 4 to 6 or thereabouts for the second, and 2 to 3¼ for the third.

I should imagine that W. P. C. will locate his troubles somewhere within the limits of my foregoing suggestions, as troubles of that nature are generally traced thereto.

H. W. Rose.

Probable Cause of Engine Runaway

Referring to C. W. Spahr's question in the Feb. 1 issue, a few years ago I had the same trouble that Mr. Spahr mentions. In this case, it was a double-eccentric Slater engine rated at 150 hp. but developing considerably more than that. Connected to the jack shaft leading from the engine was a set of bevel gears driving a crusher room and side of these gears was a sprocket with a chain drive for a set of rolls for pressing a rubber substance. Now it is nothing unusual to strip the teeth on the bevel gears and once the rubber rolls pulled so hard that the hanger supporting the shaft at that end was broken also.

On the governor of our engine, we had what we called a pin. Whenever the crusher room or the rubber rolls were going to be started, the operator of these machines would ring a bell in the engine room to let us know that they were going to start.

The fireman would get his fires ready and the engineer would put in the pin which would keep the governor from dropping down too far and shut down the engine.

When the load came on, the governor would ride on the pin, the speed dropping a little below regular and the fireman would lose from 10 to 15 lb. of steam.

I think we had the same trouble as Mr. Spahr. The load coming on and the governor riding the pin and the boiler pressure dropping cause a lower mean effective pressure, which would be caused by a lower initial pressure and a high back pressure due to working the steam practically full stroke. When the steam pressure rises to normal again and the machines that have been started are at nearly normal speed the governor will rise off the pin due to increase of engine speed causing the steam valves to cut off again.

I infer that, instead of using the pin under the governor, he used a pine stick to block up the governor in such a way as to cause unnecessary friction in the governor, causing the engine to speed up, and the centrifugal force of the governor balls were not sufficient to overcome this friction at the speed at which he took the pine stick out.

S. T. J.

Why the Short Stroke?

If P. W. M. has not yet found the correct solution to his pump problem from information given by other writers, perhaps the trouble is caused by a broken cast-iron partition between the valves and water cylinder, and the space on the suction side of the lower valves.

A simple test will prove whether the trouble is from this cause or not.

Remove the discharge valves, make the suction valves tight and fill the valve chamber (space between the valves) with water. If the partition is broken, the water will leak away very rapidly; if not, the water will leak away very slowly.

The writer had two instances of this in his experience.

W. J. Latimer.

He Eliminated the Short Stroke

Judging by the numerous letters appearing in various issues of Power Plant Engineering relative to the pump trouble of P. W. M., as related on page 158 of the Jan. 15 issue, I feel that many of the readers may be interested to know how I repaired the pump in question and eliminated the short stroke complained of.

Upon examination, I found the valve gear of P. W. M.'s pump badly worn and the brass linings so badly scored that keeping the pump properly packed was an impossibility. I bushed the valve gear by placing a washer on each side of the nut on the valve stem in the steam chest; then repacked the pump, using a layer of metallic packing between two layers of hydraulic packing, making the metallic packing by melting together 2 lb. each of lead and babbit and finely shaving the bar thus formed by means of a jack plane. The shavings were mixed with cylinder oil and graphite.

I saw P. W. M. today and he told me his pump has given him no trouble whatsoever since I did this for him.

H. M. Hunt.

Care of Rawhide Pinions

What is the best lubricant for rawhide pinions?

2. How should rawhide pinions be kept when not in use?

3. Can dried-out rawhide pinions be revived?

F. P.

Answers

Teeth of rawhide pinions should be lightly covered with a mixture of hard grease and graphite.

2. When not in use, it is advisable to coat rawhide pinions with shellac and then store them in a cool place.

3. Dried-out pinions can not be revived nor restored to their original shape. Proper storage is all required to keep them from drying.

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Production as Affecting the Industrial Situation

Coming down to the cornerstone of our industrial structure, do we not find it labeled "production"? By production, as the term is commonly used, is meant the quantity of finished articles put upon the market during a definite period of time by an individual or collection of individuals engaged in the industry. Things produced may be classified either as essentials or luxuries. What the world needs today is more essentials. People are buying, however, many luxuries entirely out of proportion to the essentials. What they buy of luxuries they pay for handsomely, what necessities they are compelled to buy they pay for grudgingly. The result is that many have gone into lines of production where the profit is greatest and money is easiest to get, leaving the production of essentials to comparatively few, and the demand constantly increasing with, naturally, an increasing market value.

In order to stabilize industry, the demand for luxuries must decrease, thus forcing more people into the production of essentials. The present wave of extravagant demands for luxuries is sure to reach its peak when the pinch for necessities is sufficiently felt, and those who establish themselves now in the production of essentials will be at the peak of their prosperity when other industries are on the decline.

The law of supply and demand is the most significant factor in the control of prices. Supply of commodities is almost wholly in the hands of the managers of industries. Demands may be due in one extreme to the need of the dire necessities of life, and in the other extreme to the fanciful desires of a mind bent on making a show of wealth. Demand is therefore only semi-controllable and lies largely with the individual in schooling his mind to be contented with the necessities and comforts of life and without the extremes in luxuries.

Two courses are therefore open, either one or both of which will lead to betterment in industrial conditions; namely, increase in production of necessities, or decrease in demand for luxuries. Every individual can practice both, and the more he can get to do likewise, the better will be the outcome.

Power plants are a necessity; the product can, however, be wasted or used extravagantly. It is the duty of the engineer to use his influence in reducing the unnecessary use of power, heat and light, thus making more power and more fuel available for the production of essentials. Whatever injures the consumer reacts against those who supply him. It he can use power efficiently, that is, profitably, he will use more of it. If he can replace man power with mechanical power at a profit, he releases the man for other essential production. This would be a great aid at the present time.

No statistics are available showing the production per man in industry at the present time, but in the Sept. 1, 1919, issue of Power Plant Engineering, a study of the demand for industrial power from 1900 to 1915 was published, which showed that the increase in value of the product per man in industry was almost directly proportional to, but about 20 per cent less than, the increase in primary horsepower per man. Thus we see that power plants have had a great influence in the production per man in industry. This influence

will continue to grow as long as machines are being installed to replace men in industry.

We are all consumers and should all be producers; our industrial fabric is made up of all industries; its weakest threads are those where class advantage is sought. This effort on the part of some injures all others and in the end weakens the cause of those who started the agitation. Altruism is the only basis for general welfare, and the spirit of altruism must prevail in all industries and all classes, if economic disaster is to be avoided.

The Super Power Zone

At a recent meeting of the American Institute of Electrical Engineers held at New York City, a number of engineers intimately acquainted with the subject and in a position to speak with authority contributed a symposium on the necessity of and advantages to be derived by the establishment of a super power zone to cover the Northeastern Atlantic States. According to suggestions advanced, this zone would extend from Washington to Boston and inland for a distance of from 100 to 150 mi., thus embracing the most important industrial centers along the seaboard.

In view of the fact that the application of electric energy to our industries is progressing at a tremendous rate, due primarily to the increasing use of labor-saving machinery and devices and the ever-decreasing quantity and lowering quality of fuels available for power producing purposes, the desirability of such a scheme for the production and distribution of power is obvious. It is estimated that under existing conditions the territory to be included within the proposed super power zone today consumes coal at the rate of 70,000,000 tons annually, which, by further electrification of industries and railroads and the interconnection of all supply sources and transmission and distribution systems may readily be reduced to 30,000,000 tons, or, in other words, a saving of at least 50 per cent of fuel costs may be expected to result. Primarily this is to be brought about by the utilization of power plants equipped with the most economical types and sizes of generating units located so as to insure continuity of service and minimum transmission losses. This would appear most readily accomplished by placing the plants as near as possible to the mouths of the mines, yet not at any appreciable distance from the centers of greatest loads. As an added precaution against possible fuel shortage, as in the event of mine labor trouble, a number of sufficiently large tidewater plants operating in conjunction with the Susquehanna, Delaware and St. Lawrence Rivers water powers could undoubtedly be of material assistance in bridging over any emergency which might arise.

From a standpoint of economics, the highest possible transmission voltage should be utilized, and it has been mentioned that possibly 220,000 v. or more might be entirely practicable, for already apparatus capable of handling such high potentials is available. Relative to the probable means of distribution, P. H. Thomas suggested the erection of a main trunk line from Washington to Lawrence, Mass., with three main taps for the supply of energy.

The total investment for the development is estimated at $150,000,000, this to cover the cost of super power plants having a combined capacity of 900,000 kw. and 700 mi. of transmission lines with necessary equipment. To finance this proposition, U. S. Murray makes mention of a number of possible schemes, any one of which might be employed. He suggests the issuance of the necessary securities by the federal government, by private interests or the state, or by private interests with federal government or state guarantees.

Viewed as an engineering problem, the scheme is feasible and, in the interest of fuel conservation and reduced power costs, is highly commendable. It is, however, a natural development of the central station and is merely a step forward in the extension of an existing network of transmission and distribution lines already well covering the proposed zone. It would therefore appear advisable to interconnect all of the various sources of supply and transmission system at such points and at such times as interconnection may prove most advantageous and to discontinue the operation of the older, more obsolete and inefficiently operated plants as occasion may require and superstations are added to the system. In this way the maximum existing equipment might be utilized and the initial investment materially reduced. This arrangement would also provide sufficient flexibility to care for shifting loads.

Regardless of the benefits to be derived by the creation of a super power zone, both by producer and consumer, its field will be limited. Like the central station, its service cannot be universal. For this reason, the estimated reduction in fuel consumption is, in fact, improbable. As much fuel will still be required for heating purposes, and in innumerable manufacturing processes, steam is absolutely essential, so that, regardless of the most alluring rates which it be possible to offer the consumers of power, many industries will find it more economical to continue the operation of their own plants. In many of these, the prime movers function as reducing valves; the power generated is in reality a by-product and the cost of its production is therefore practically nil.

Why the government, federal or state, should underwrite or even guarantee any of the securities which might be issued to finance the establishment of a super power zone is difficult to state. As before stated, this is a development of the central station and as in the past, these have always been financed by private interests, so should any extensions or developments of the central station industry be financed.

ELECTRICAL accidents call for quick action. When a worker receives an eelctrical shock, the first thing to be done is to break the contact. The Industrial Commission of Wisconsin gives the following suggestions for breaking contact safely:

If there is a switch at hand, cut off the current at once.

If there is no convenient switch, remove the body from the circuit by means of any dry non-conductor, such as a piece of wood, a pick or shovel having a dry wooden handle, a sling of cloth or a garment such as overalls, the victim's clothing, the hands when protected by several thicknesses of dry cloth.

As a last resort, the circuit may be broken by short-circuiting, thereby causing the circuit-breaker or the fuses to open.—Factory.

Air Washer and Cooler for Generators

How One Power Plant Superintendent Increases Capacity and Helps to Offset Rising Costs.

By Alfred M. Bacon*

THE power station of today is a great testing laboratory. Equipment which has a place there has it only because the particular machine has demonstrated its economic right to remain; because its performance figures out on the right side of the ledger. Every daily operation is closely watched. The power house superintendent knows, by his charts and figures, whether his efficiencies are up to the mark, and when he takes his visitor on a round of the plant, proudly points out what mechanical stoker, what forced draft, what generator is doing its work, and always he has a "why" attached to his remarks. He has to be "long" on why's of all kinds on his particular job, because with many and oftentimes difficult electrical questions constantly coming up, he must always be prepared with the facts to decide which is the most economical way to get the best results.

There is a greater need today than ever before in power plant operation for economy, owing to the greatly increased cost of all raw materials, notably coal, oil and labor. All this on the one hand. On the other, the firm opposition of the public to take any increase in price of their current, either in the form of light and heat or in street car transportation. The strong protest which arises when any such suggestion is made, is well known. The power house superintendent finds himself therefore obliged to meet a situation of opposite forces, one, the factor of receipts, refusing to budge an inch. It reminds one of the favorite old, school catch-question, as to what would happen if an irresistible force encountered an immovable obstacle. At date of writing, no satisfactory answer has been recorded, yet it is something like this that the power plant executive is asking himself and is having to work out.

At the Quincy Point Power Station of the Eastern Massachusetts Street Railway Co., it has been demonstrated that turbine generators earn more by air cleaning and cooling.

Increased output from the same station with the same capital investment, of twice the usual amount means that the interest on the investment is halved; interest on the floor space occupied by the machine is halved and the same with all fixed charges. This saving becomes additional profit. The proportion here stated of increasing to twice the capacity is used simply for illustration purposes, not as statement of fact. Increased capacity, however, in varying capacities, can be realized on any type of generator by air cooling. If this increase amounts to 10 per cent and output is actually advanced 1000 kw. per hour, the earnings are increased and these are nearly net, since there is no increase in overhead (after the initial expense of installing the cooling system), although of course there will be a slightly increased cost of operation, in coal and oil, the water in this case being figured free. This extra operating expense will not, however, be anywhere near proportional. With air cooling on his generators, the power plant man can effect this increased capacity without danger to the windings. Thus, when confronted by increased cost of operation, he can increase his income materially and safely by means of air cooling his generators.

A superintendent of a large central station, speaking of the air washing and cooling apparatus which he uses, says:

"We consider this a very important part of our equipment and that it has more than paid for itself. The original cost of the turbo-generator which we use, is less because of the less amount of copper, or, more strictly, the lighter copper used on the windings; but our air cooling permits us to use this type and to realize the saving in price between it and the type with more expensive winding and no air cooling. Of course, the initial cost of the air cooling system must be reckoned with, but to offset this, we must consider the important points that in the case of air washing there is no shutting-down of the machinery for cleaning; there is no loss of radiation owing to collection of dirt and dust; no burning out of windings (an expensive occurrence) due to not cleaning the machine often enough. Continuous operation is possible and therefore fixed charge cost per kilowatt is reduced to the lowest point.

"Generators not equipped with air washers must be shut down for cleaning at least once a week, which takes 2 hr. of a man's time. On our five generators this, of course, amounts to quite an item. I have not had our air-cooled generator cleaned for over 2 yr. and it is running perfectly now. You ought to see the amount of dirt that we take out from the washer after just one day's operation.

"The limit of load which it is safe to carry on any electrical generator is directly and definitely determined by the temperature which it will develop when carrying the load. It is absolutely essential that air passages between the laminations be maintained free of dust. Any restriction of these passages will interfere with the flow of air that is necessary to prevent excessive temperature.

"Dust or soot in the air soon collects in the air spaces and such accumulations are especially rapid where any oily vapor can accompany the ventilating air. Air, circulating in this oily atmosphere, destroys the varnished cambric insulation and it is this dirt which cuts down radiation.

"When making their capacity guarantees, electrical manufacturers require that a definite amount of cool, clean air must be supplied, and we decided that the cheapest and most satisfactory way to obtain this was by using the air washer."

U. S. Civil Service Commission announces an examination, April 20, for mechanical aid, to fill a vacancy in the Department of Ordnance, Navy Yard, Washington, D. C., at $10.56 a day, and vacancies in positions requiring similar qualifications, at this or higher or lower rates of pay. Competitors will be rated on general and technical education and experience in machinery and ordnance, experience in editorial work or specification writing, publications, reports, or thesis. Apply for Form 2118.

* With the B. F. Sturtevant Co.

Pompton Lakes Hydroelectric Plant

THREE THOUSAND population is a rather inconspicuous figure in this country of large cities, yet when it comes to initiative, the town of Pompton Lakes, N. J., demands recognition. Proof of this claim may be found in the development of its municipal hydroelectric plant.

The former municipal power station was typical of a large number of plants established throughout the United States. Motive power for the two 50-kw. generators was provided by 75-hp. gas engines, and a daily consumption of from two to three tons of coal was essential. In addition to this, the staff expense was comparatively high as it was necessary to employ a superintendent and four assistants.

With an increasing use of power, the authorities found that the old station would not be large enough to supply the demand and it was decided to build a new power plant on a more generous scale, and also on a more economical basis, utilizing as motive power the

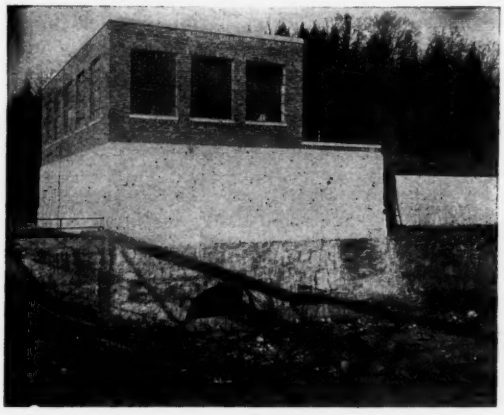

FIG. 1. POMPTON LAKES HYDROELECTRIC POWER STATION

overflow from Pompton Lakes. These lakes, which are fed by the Ramapo river, are comparatively close to the town.

A subscription was raised, and the dam was purchased from the Corning estate by the municipality. New headgates were installed and a flume, 100 by 24 by 10 ft. was built from the dam to the power station, the overflow operating two S. Morgan Smith vertical turbines of approximately 125 hp. and 225 hp. capacity respectively at a 21-ft. head. Woodward oil pressure governors 6 by 12-in. and 5 by 9-in. are used.

The turbines are direct-connected to vertical generators of 100-kv.a., 300 r.p.m. and 250 kv.a., 200 r.p.m. capacity respectively, the combined weight of the water wheel and generator rotors being carried by a Kingsbury thrust bearing supported by the upper guide bearing bracket of the generator. As the peak load at present is only 85 kw., the smaller unit develops sufficient power to meet this demand, but both units are operated alternately. The exciters are belt driven by one quarter-turn belt and idler. The generators operate at 2400-v., 3-phase, 60-cycle with 125-v. excitation.

A balanced regulator furnishes current for street lighting at 2400-v.

The building is a 30 by 60-ft., two-story, brick structure, concrete floored, and with a general office, transformer room, generator room and a garage, affords more than ample space.

In addition to house lighting for the town, this plant furnishes current for approximately 30 mi. of street and road lighting, operates the pumps that supply the local

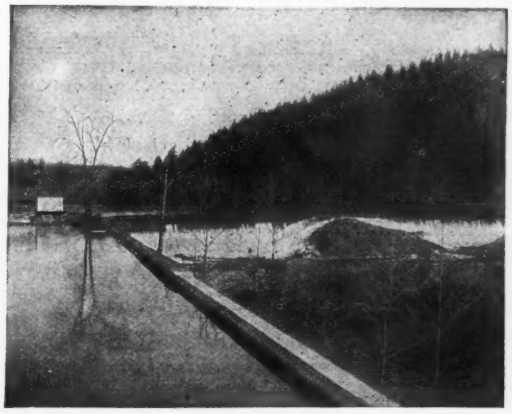

FIG. 2. DAM AND FOREBAY AT POMPTON LAKES

reservoir and is used by five factories, and an electrified coal elevator. In the near future electric power from this station will also be used by the towns of Riverdale, Pompton Plains, Haskil and Midvale.

Efficiency of this power plant is unusually good and it is stated that the net operating cost is only about one-third of that of the old station. Certainly with the prevailing coal situation, Pompton Lakes is in an enviable position with regard to its power supply.

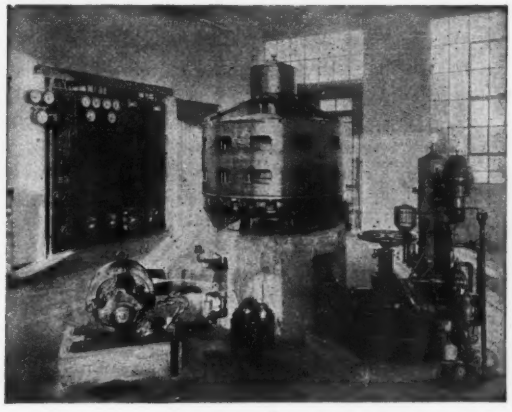

FIG. 3. INTERIOR VIEW OF POWER HOUSE

J. A. Burrell, chief engineer, and two assistants constitute the staff, as compared to the staff of five formerly required to operate the old station.

IT IS ANNOUNCED in Wall Street Journal that the greatest activity in the oil fields of United States east of the Rockies in January centered in north Louisiana and north Texas. In the former, 58 completions were recorded, resulting in 215,000 bbl. of new production. In north Texas region, 647 completions resulted in 160,738 bbl. new output.

Trade News

DATA CONCERNING the registration of trade marks and copyrights in various countries of the world are contained in the January number of Facts.

IMPERIAL PACKING CORPORATION announces the opening of its store and offices at 191 Greenwich St., New York City.

MORSE CHAIN CO. has recently opened two new offices, one in the Lexington Building, Baltimore, Md., in charge of E. R. Morse, the other in the Harrison Building, Philadelphia, Pa., in charge of M. H. Rodda.

A. T. SHURICK, mining engineer, and recently identified in an editorial capacity with various coal journals, has become associated with and been elected vice-president of F. C. Thornley & Co., Inc., constructing and consulting engineers, New York.

AT A recent meeting of the stockholders of the Buffalo Forge Co., new officers were appointed as follows: Henry W. Wendt, president; Edgar F. Wendt, vice-president and treasurer; Henry W. Wendt, Jr., vice-president and secretary; C. A. Booth, vice-president and sales manager. The new directors include the above-named officers, and, in addition, H. S. Whiting.

THE WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J., announces the publication of the 1920 edition of its popular "Steam Tables for Condenser Work." This is the fifth edition. Every engineer who deals with the condensation or evaporation of steam should have one of these handy tables. The pressures below atmosphere have been especially calculated for this book by Prof. Marks.

THE MAHER ENGINEERING CO., located at 30 N. Michigan Boul., Chicago, announces the opening of a branch office at 708 Schofield Building, Cleveland, Ohio, handling the distribution of constant and variable speed, high and low pressure engines, centrifugal pumps, and centrifugal fire pumps, hydraulic balers and presses. The office will be under the management of Lincoln E. Maher.

AMERICAN STEAM CONVEYOR CORPORATION announces the appointment of the Kon-Wald Engineering Co., Mutual Life Building, Buffalo, N. Y., as its representative in Buffalo and western New York. F. A. Konzelman, manager of this company, is well known in the engineering circles in that vicinity.

The Brooks-Fisher Co., Candler Building, Atlanta, Ga., has been appointed Southeastern representative of the same company. This is a comparatively new concern, having been organized early last summer to carry on a business of manufacturers, agents and contractors. J. M. Fisher was for 15 yr. in the erection department of the Babcock & Wilcox Co., the last six as district superintendent for the Atlanta territory. E. A. Brooks, the other member of the firm, was, up to the time of its organization, assistant sales manager for the Atlanta office of the Babcock & Wilcox Co. He is a graduate of Georgia Technical College and an associate member of the American Society of Mechanical Engineers, and has had considerable experience both in the operating and the sales end of the boiler business.

Both Mr. Fisher and Mr. Brooks are hard workers and real live wires, being well acquainted with the engineers, plant owners and operatives in their territory.

THE MONO CORPORATION of America, Buffalo, N. Y., announces that it has purchased the entire stock of Mono apparatus and accessories from the F. D. Harger Co. This includes all rights for the manufacture and sale of the company's various types of Mono apparatus. It is to be noted that F. D. Harger has not severed his connection, but will serve as general manager of the new corporation. A service and inspection department, connected with the laboratory, is now in operation and a competent chemical engineer in charge. Capable erectors will be placed at the disposal of customers in connection with the erection of new work and regular inspection trip will be arranged to visit existing installations, with a view to bringing about closer co-operation between the customer and the corporation.

IN A PAMPHLET entitled "High Efficiency Centrifugal Pumps," the De Laval Steam Turbine Co. has described official tests made by the city of Minneapolis upon a 20-in. De Laval centrifugal pump driven by an induction motor and similar tests made by the city of St. Paul upon two 12-in. De Laval centrifugal pumps driven by synchronous motors.

PAGE water-tube boilers are the subject of a new catalog which explains the construction and advantages of these boilers. Among the illustrations are reproductions of drawings showing Page boilers with various means of firing; also, a series of halftone views illustrating a number of boiler installations.

Page Boiler Co., 817 Larrabee st., Chicago, will be glad to send a copy of the catalog to any reader who is interested.

PAMPHLETS entitled "How Successful Manufacturers Are Making Mechanical Powers Produce More and Cost Less," and "The Factory Executive Meeting Tackles Coal Buying," were lately published by Fuel Engineering Co., of New York. The former relates the experience of several plants before and after the company undertook the technical direction of their power production and use; in the latter, the purchasing agent of a factory describes his experiences and conclusions, emphasizing the value of diversity and breadth of experience in coal buying.

AMERICAN STEAM GAUGE & VALVE MFG. CO.'S illustrated catalog No. 65, recently received, covers gages, valves, indicators, steam traps and kindred appliances for governing, indicating, measuring, recording and controlling steam, water, air, gas, oil, ammonia and all other pressures.

THE STANDARD FUEL OIL ENGINE CO. has just published an attractive catalog describing its Diesel type oil engine. The book is well illustrated with halftones and line drawings showing details of construction, parts and installations. The text matter takes up a general description of the engine and then goes into a detailed description of the various parts and specifications of the materials used.